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SECOND INTERNATIONAL CONGRESS ON GLASS

July 2 to July 11, 1936

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GLASS ◆ FUELS ◆ REFRACTORIES

For Program Outline of Meeting see the April issue of
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S. S. Scythia (Cunard) sails from New York, June 19
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THE PACKING OF PARTICLES: EMPIRICAL EQUATIONS FOR INTERMEDIATE DIAMETER RATIOS*

By A. E. R. Westman

Abstract

An empirical equation was developed which could be used for representing the packing characteristics of systems consisting of mixtures of particles of two sizes. Application to data previously published gave a definite indication of a relation between the parameter of the equation and the diameter ratio of the particles.

I. Introduction

In a previous paper[1] it was shown that if experimental conditions were controlled, reproducible values for the volumes occupied by mixtures of different sizes of particles could be obtained. It was also shown that for mixtures of two sizes of approximately spherical particles, theoretical considerations gave the density of packing for the two limiting cases of diameter ratios equal to unity and infinity, provided the density of packing of each size alone was known.

For diameter ratios intermediate between these two limits, considerable data were presented, both in tables and in diagrams, in which curves were drawn through the points graphically. It is the purpose of this paper to present empirical equations which can be used for such intermediate diameter ratios.

II. Nature of Problem

The nature of the problem can be explained best by reference to Fig. 1, which shows the packing characteristics of systems consisting of mixtures of coarse and medium particles, the diameter ratio being 6.3. The composition of the mixtures is shown by the horizontal scale, x being the true volume of the coarse particles, and y, the true volume of the medium particles for a total true volume of unity. The vertical scale is a scale of volume per unit true volume of mixture. Thus, C gives the experimentally determined packed volume of the coarse particles and M, that of the medium particles per unit true volume; the other points give the packed volumes of mixtures expressed in the same way.

It was shown in the previous paper that for diameter ratios of unity, the packed volume, v, was given by the line, CM, having the equation

$$v = Cx + My \tag{1}$$

and for an infinite diameter ratio, the values of v were given by the line joining M with unity at the left side of the diagram and the line, CA, obtained by joining C with the zero point at the right side of the diagram, the equations of these lines being

$$v = Cx \tag{2}$$

$$v = x + My \tag{3}$$

For intermediate diameter ratios, the values of v lie on curves similar to that designated Va in Fig. 1, intermediate between CM, the line for a ratio of unity, and the lines for an infinite ratio.

It was evident that the most useful empirical equation would be one which could be fitted to points such as those in Fig. 1, with the use of as few constants as possible, and one which would resolve into the line, CM, at one limit and the two lines at the other limit.

III. Development of Empirical Equation

An empirical equation was developed by consideration of an equation of the general form

$$a^2 + 2Gab + b^2 = 1 \tag{4}$$

For $G = 1$, this resolves itself into a linear equation of the form

$$a + b = 1 \tag{5}$$

and for $G = \infty$, it takes the form

$$ab = 0. \tag{6}$$

By making appropriate substitutions for a and b, using equations 1, 2, and 3, equation 4 can be converted into an equation which becomes equation 1 for $G = 1$ and either one of 2 or 3 for $G = \infty$.

In this way the conic 7 is obtained, having only one parameter, G, which varies from curve to curve.

* Received August 12, 1935.

[1] A. E. R. Westman and H. R. Hugill, "The Packing of Particles," *Jour. Amer. Ceram. Soc.*, 13 [10] 767–79 (1930).

$$\left(\frac{v - Cx}{M}\right)^2 + 2G\left(\frac{v - Cx}{M}\right)\left(\frac{v - x - My}{C - 1}\right) + \left(\frac{v - x - My}{C - 1}\right)^2 = 1 \qquad (7)$$

Equation 7 can be given in a more explicit form but is more convenient for computations in the form given.

An alternative method of development of equation 7 is to start with a general conic equation and introduce the conditions that it must reduce to 1 or 2 and 3 for certain values of the parameters. Another variation is to start with the equation

$$(a + b)^n + tab = 1 \qquad (8)$$

instead of equation 4. This gives equation 7 for $n = 2$ and higher degree equations for other values.

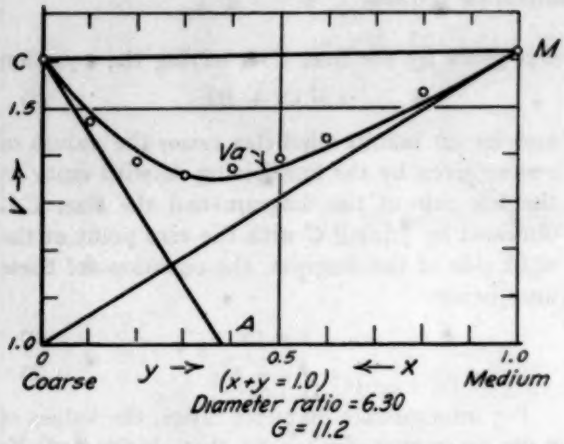

FIG. 1.—Comparison of observations and empirical curve for packed volumes of mixtures of coarse and medium sand.

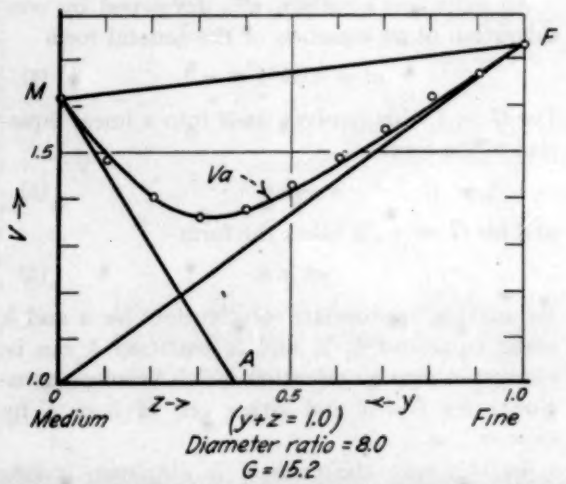

FIG. 2.—Comparison of observations and empirical curve for packed volumes of mixtures of medium and fine sand.

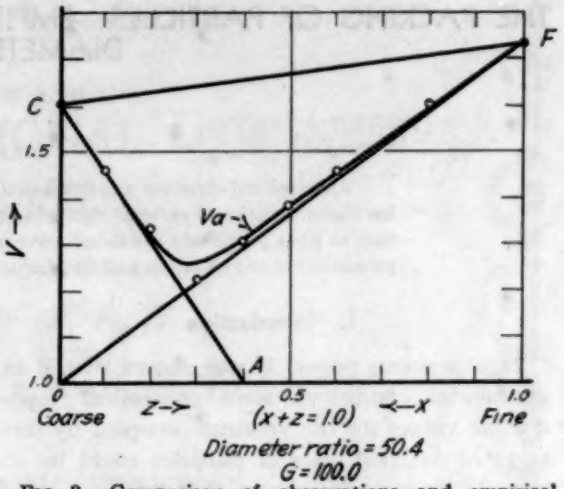

FIG. 3.—Comparison of observations and empirical curve for packed volumes of mixtures of coarse and fine sand.

IV. Application of Empirical Equation

In order to determine whether equation 7 could be used to represent packing data satistorily, it was used to fit curves to the data previously reported as shown in Figs. 1, 2, and 3. Due to the complexity of the calculations, no attempt was made to determine the best value of G in each case. For Figs. 1 and 2, G was given the value required to put the curve through the experimentally determined point for the densest

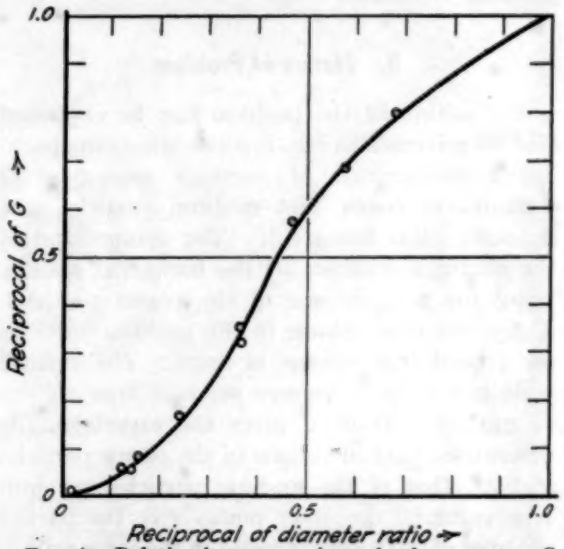

FIG. 4.—Relation between reciprocals of parameter, G, and diameter ratio for experimental data obtained with sand and lead shot.

mixture; in Fig. 3, the point for $Z = 0.4$ was chosen instead, since there was reason to believe from the experiments that the point for the densest mixture was too low due to excessively long packing. Disregarding this point, the average difference between observed and calculated values for the three systems was 0.01 for values of v ranging from 1.309 to 1.739. The usefulness of the equation, however, can only be determined accurately by trying it with more data than were available from our experiments.

V. Relation between G and Diameter Ratios

If a relation between G and the diameter ratio could be established by experiment, then, given the packing characteristics of the end members and their diameter ratio, the packing characteristics of any binary system could be calculated. To investigate this possibility, values of G were calculated for all the data on the packing of sand and lead shot which were given in the previous paper,[1] and their reciprocals were plotted against the reciprocals of the corresponding diameter ratios. As shown in Fig. 4, this gave a definite indication of a relation between G and diameter ratio. Many more data, however, are needed to verify this statement.

VI. Summary

An empirical equation was developed by means of which the packing characteristics of two-size particle systems could be represented using only one parameter. The application of this equation to the data available showed satisfactory agreement between observed and calculated values and a definite indication of a relation between the parameter of the equation and diameter ratio.

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THE FLOW OF CERAMIC BODIES AT ELEVATED TEMPERATURES*

By F. H. Norton

Abstract

A study is made of the flow characteristics of a porcelain over a considerable range of stress and temperature. In the range of these tests, where the rate varied by a million to one, no lower limit was found to the flow. The flow always reached a steady rate, but this took as much as 400 hours in some cases. The relation of plastic flow to other types is discussed as well as the application of the flow diagram to the load test and the fusion point.

I. Types of Flow

There are three flow régimes of interest in the study of the slow deformation of ceramic bodies. The first is viscous flow, so well exemplified by heated glass. Here the rate of flow is directly proportional to the stress, even over a large range of rates, although considerable time and deformation must elapse before this type of flow becomes uniform. The cause of this initial period in a homogeneous material like glass is not yet understood.

The second type of flow is generally called plastic, although the term has other associations. After an initial period of decreasing rate, the flow becomes steady and is then roughly proportional to the fourth power of the stress. This type does not follow an exact law, for the exponential varies between 3 and 5. Metals above the recrystallization temperature show plastic flow, as do ceramic bodies containing a mixture of crystals and glass. It would seem that a plastic substance must be composed of rigid particles in a softer matrix.

The third type of flow is known as elastic. There is an initial elongation and then apparently a zero flow rate even at stresses up to the breaking point. Owing to the difficulties of measurement, this type of flow has not been carefully studied but seems to apply to metals below the recrystallization temperature. It is also believed to represent the conditions in ceramic bodies when the glassy phase is absent. The writer hopes to carry out studies at very low flow rates, for it

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 29–April 4, 1936 (Refractories Division). Received December 12, 1935.

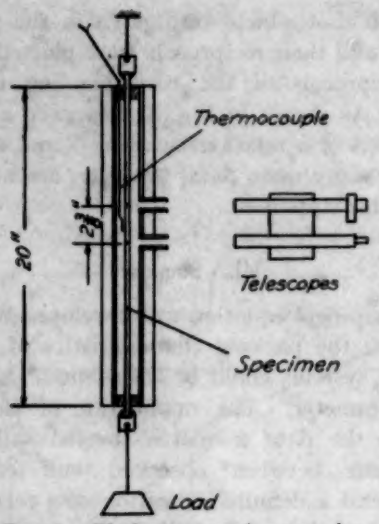

FIG. 1.—Platinum-wound creep furnace.

is well known that no solid is perfectly elastic.

Viscous flow has been studied extensively in glass[1] and plastic flow in metals.[2] But plastic flow in ceramic bodies has received little direct attention; only one investigation[3] has gone into the matter at all thoroughly, and it did not bring out the significance of the flow types. The flow of ceramic bodies, however, is well known, as for example, in the deformation of ware in firing and with refractories under load.

II. Test Specimens

In the present investigation, a porcelain body is stressed to produce a wide range of flow rates over a considerable temperature interval. The body was made up as follows:

	(%)
Potash feldspar	25
Flint	25
No. 1 English china clay	35
Kentucky ball clay	15

Bars, 20 inches long and $^5/_{16}$ inch in diameter, were extruded by a vacuum auger. The ends were upset in a wooden die for the tension grips. After drying, the rods were hung by one end and fired for two hours at 1300°C.

III. Furnaces

Owing to the great range of flow rates studied, over a million to one, three types of furnaces were used to cover the field. The slower the flow, the more carefully must the measurements be made.

The lower rates were measured in special platinum-wound creep furnaces (Fig. 1). The temperature control,[4] which depends on the expansion of the furnace tube, is simple and gives excellent regulation (Fig. 2). A constancy of temperature of ±0.5°C can be depended on over long periods. The elongation of the specimen is read by means of micrometer telescopes to within 20 parts in a million.

More rapid rates were determined in a Globar furnace, shown in Fig. 3. An even temperature

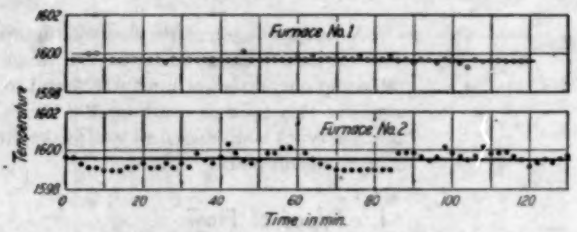

FIG. 2.—Temperature control in °F.

was maintained over the 6-inch gage length, and by means of an induction regulator the temperature was hand-controlled within ±3°C during the test period. The temperature was measured both by platinum couples and an optical pyrometer. As the specimen was horizontal and supported in a trough of insulating fire brick, there was a frictional error at the small loads which was roughly corrected for, but below stresses of 10 pounds per square inch this furnace is not particularly suitable.

For this reason, the furnace shown in Fig. 4 was used for the higher temperatures. The test

[1] (*a*) V. H. Stott, D. Turner, and H. Sloman, "Effect of Thermal Treatment on Glass as Shown by Precise Viscometry," *Proc. Roy. Soc.* [London], **A112**, 499 (1926); *Ceram. Abs.*, **5** [10] 305 (1926).
(*b*) H. R. Lillie, "Viscosity Measurements in Glass," *Jour. Amer. Ceram. Soc.*, **12** [8] 516–29 (1929).
(*c*) H. R. Lillie, "Viscosity of Glass between the Strain Point and Melting Temperature," *ibid.*, **14** [9] 502–11 (1931).

[2] (*a*) F. H. Norton, The Creep of Steel at High Temperature, McGraw-Hill Book Co., 1929.
(*b*) P. G. McVetty, "Creep of Metals at Elevated Temperatures," *Iron Age*, **127**, 868 (1931).
(*c*) H. J. Tapsell, Creep of Metals, Oxford University Press, New York, 1931.
(*d*) A. Nadai, "Creep of Metals," *Mech. Eng.*, **54** [6] 443–44 (1932).
(*e*) A. E. White and C. L. Clark, "Creep Characteristics of Metals at Elevated Temperatures," *Trans. Amer. Soc. Steel Treating*, **21** [1] 1–16 (1933).

[3] J. H. Partridge and G. F. Adams, "Studies of Clay Mixtures for Glassmelting Pots. III, Flow at High Temperatures of Pot Clay Refractories under Stress," *Jour. Soc. Glass Tech.*, **15**, 190–208 (1931).

[4] F. H. Norton and J. A. Fellows, "A New Device for Creep Testing," *Metal Progress*, **24** [4] 41–43 (1933).

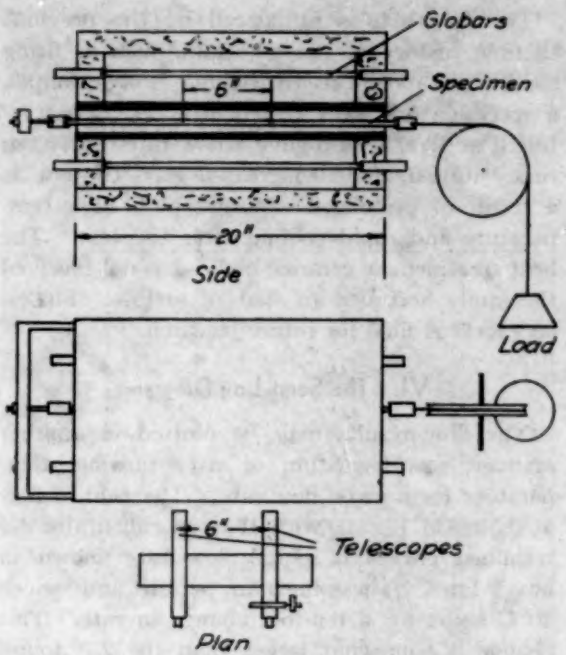

FIG. 3.—Globar furnace.

rod was loaded only by its own weight so that the stress varied along the heated section; and the temperature distribution was not as good as with the other furnaces. As only rapid rates were attempted, however, the results should have a fair precision.

IV. Extension Curves

In Fig. 5, there is shown the time-extension curves for two porcelain specimens over a thousand-hour period. It will be noted that there is an initial period of rapid change in rate,

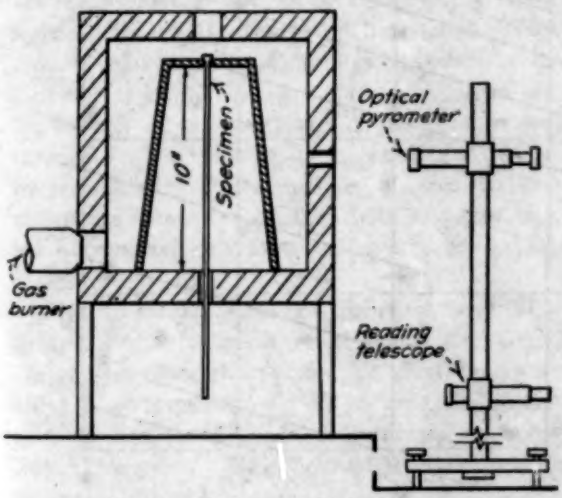

FIG. 4.—High-temperature furnace.

a second period of slow rate change due to crystal growth, and finally a uniform rate showing a stable structure. These curves are identical in shape with the time-extension curve for a soft

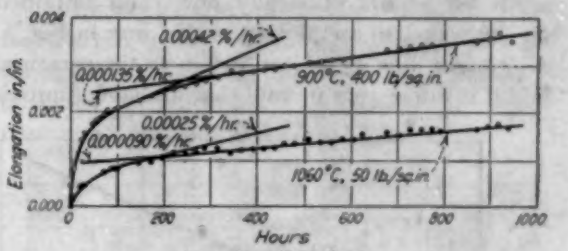

FIG. 5.—Slow flow.

metal at room temperature or a steel at elevated temperatures and are characteristic of a plastic material.

The time-extension curve of the porcelain at a higher rate is shown in Fig. 6. Here, the time is so short that no structural changes occur. Therefore we have the initial or "strain-hardening" period changing directly into the uniform flow condition.

The curve in Fig. 7 shows an even more rapid flow, which indicates a uniform rate as before, but the initial portion of the curve could not be

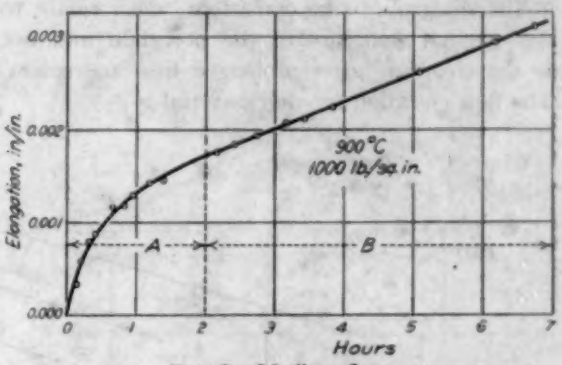

FIG. 6.—Medium flow.

obtained in the short time available without a recording device.

V. The Log-Log Diagram

To show the relation between stress and flow rate, the plotting method used by the author[10] for metals has been adopted. It is found that when the logarithm of the stress is plotted against the logarithm of the flow rate a straight line results over a large range of flow. The slope of this straight line gives the exponent in the flow equation. In the case of metals at very

low rates of flow, the slope of the log-log curve becomes steeper, indicating viscous flow. This method of plotting has no fundamental significance but is convenient for interpolating values.

All the values of steady flow rates obtained on the porcelain are plotted in this way in Fig. 8. A straight line is shown for each temperature, and it is interesting to note that all have approxi-

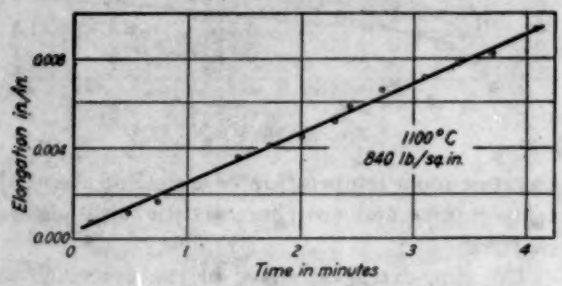

FIG. 7.—Rapid flow.

mately the same slope. The values at the lowest flow rates are indicated by two points at each temperature. The higher ones fall on the straight line and represent the flow at the end of the strain-hardening period, while the lower ones are to the left of the line and represent equilibrium flow after structural changes have taken place. That is, the diagram, to be consistent, must relate to the original structure of the porcelain and not to the structure after prolonged heat treatment. The flow equation for this material is

$$V = kF^{3.23}$$

Where V = flow velocity
F = stress

The flow rate is influenced by the previous thermal history of the porcelain, such as firing conditions and heat treatment. For example, a specimen originally tested at 1300°C, was retested at 1000°C and gave a flow rate nearly ten times normal, due to increased glass content as a result of prolonged exposure at a high temperature and rapid cooling after the test. The heat treatment of ceramic bodies has not received the study accorded to that of metals. This is an excellent field for future research.

VI. The Semi-Log Diagram

The flow results may be plotted in another manner, *i.e.*, logarithm of stress against temperature for a given flow rate. The field of flow is shown in Fig. 9, with the experimentally determined curves of equal flow rate shown in heavy lines. These lines are parallel and spaced 40°C apart for a ten-fold change in rate. This change is somewhat larger than the 25° found in the case of firing an electrical porcelain,[5] which may be due to the difference in the quantities measured.

The regions of the flow field outside of that actually measured can at present only be conjectured, but since certain analogies may be found with the case of metals, a fairly accurate picture can be formed. Field *A* represents the region of uniform flow, the upper side of which

[5] F. H. Norton and F. B. Hodgdon, "Influence of Time on Maturing of Whiteware Bodies: I," *Jour. Amer. Ceram. Soc.*, **14** [3] 177–91 (1931).

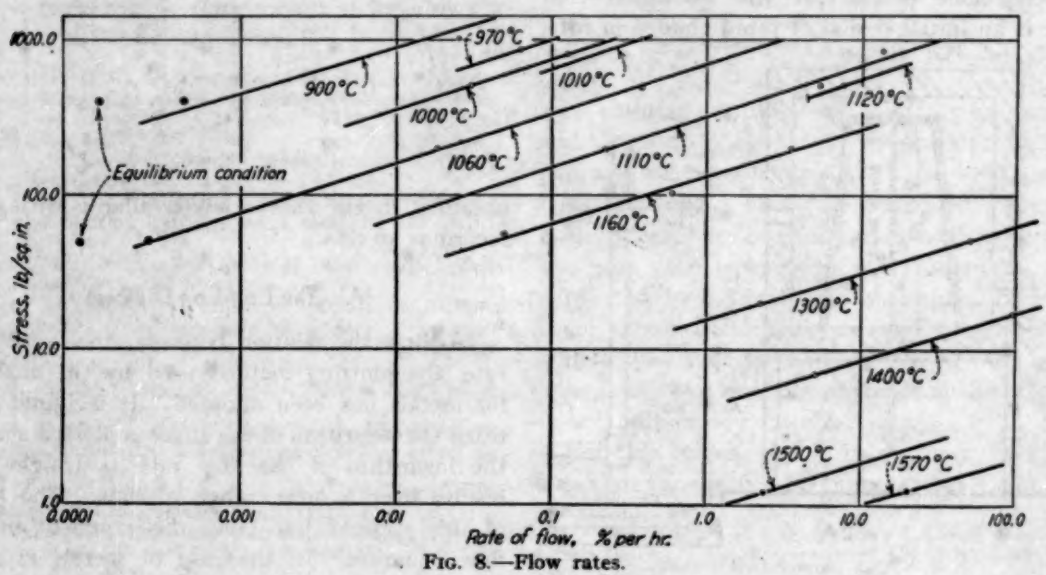

FIG. 8.—Flow rates.

has been explored. As the temperature is reduced, the flow becomes so slow that it can not be detected with any of the present apparatus. It is believed, however, that when a certain temperature is reached the elastic field *B* is entered where no steady flow is produced even with loads up to the breaking point. This is the condition

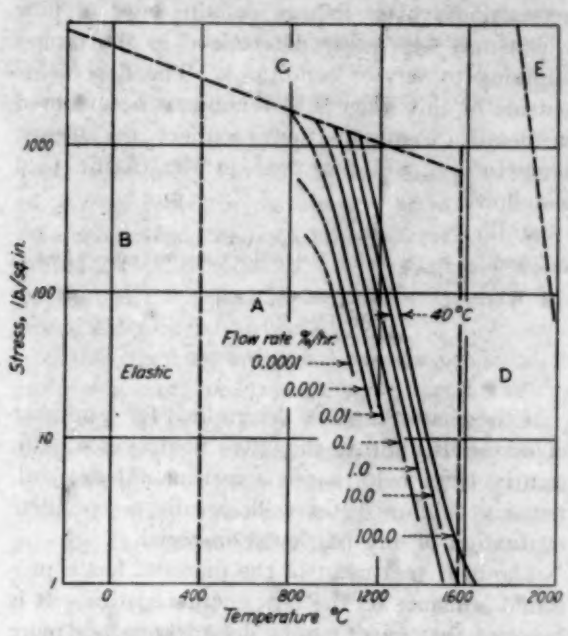

FIG. 9.—The flow field.

of iron or nickel at room temperature. We do not know whether this boundary is sharp or gradual.

As the stress is increased in either field, *A* or *B*, we come to the boundary of *C*, above which the material can not support the stress for an appreciable length of time. The transition from *B* to *C* is sudden and definite but between *A* and *C* is not as clearly defined, since a specimen may be broken at a lower load if the time is long enough. Theoretically, however, if the load is decreased with the reduction of area to keep the stress intensity constant with elapsing time, the elongation can keep on at a uniform rate indefinitely.

The transition between fields *A* and *D* is probably the temperature at which the last of the crystal phase disappears; *D*, then, represents the field of viscous flow. At higher temperatures and stresses the field, *E*, representing turbulent flow, is entered. The boundary is defined by Reynold's number,

$$\frac{VL}{\mu}$$

Where V = flow rate
L = linear dimension
μ = kinematic viscosity

It should again be emphasized that the exact boundaries outside of the measured area are conjectural, but it is probable that régimes of flow are approximately as indicated. These flow types are summarized in Table I.

TABLE I

Field	Structure of body	Type of flow	Condition
A	Crystals and glass	$V = kF^4$	Plastic
B	Crystals or crystals and glass	$V \rightarrow 0$	Elastic
C	Crystals or crystals and glass	$V = \infty$	Fractured
D	Glass	$V = kF$	Viscous
E	Glass	$V = kF^{1/3}$	Turbulent

This general field of flow should apply to any ceramic body composed of crystals and glass.

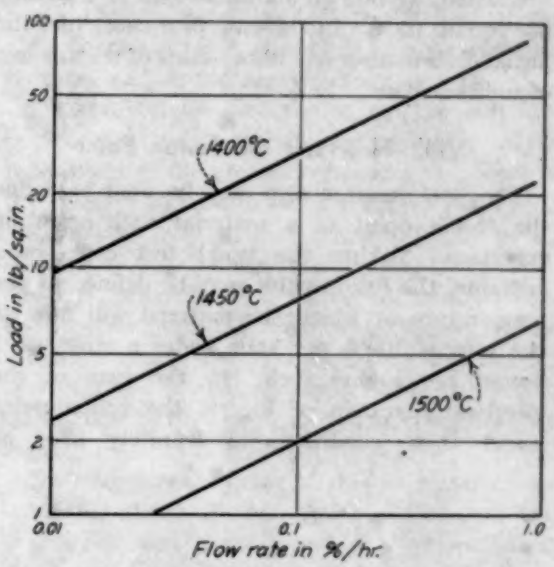

FIG. 10.—Flow curves for fire brick in compression.

The more refractory materials will move the whole field to the right while weaker materials will lower the diagram. In the case of a pure crystalline substance, the elastic range probably changes suddenly to the viscous at the melting point, although there is some evidence of very slow flow in completely crystalline materials. On the other hand, there is reason to believe that a glass shows no sudden transition from viscous to elastic flow.

VII. Flow in Relation to the Load Test

The flow diagram will assist in interpreting some of the physical properties of refractories for practical use. For example, load tests have been made on fireclay brick in the same way as the tension tests with porcelain, and although more precision is needed than obtainable with the present equipment, the results follow the laws of plastic flow.

As a concrete case, suppose it is desired to determine the safe load for the piers in a furnace where the temperature is 1400°C, the furnace life is 1000 hours at operating temperature, and a maximum allowable deformation of the pier is 10%. The usual load test does not permit us to calculate this load, but the flow diagram readily gives the answer. Figure 10 gives flow rates for a high-heat duty brick at several temperatures and loads. Following up the vertical line at the flow rate of 0.01% per hour until the 1400° curve is reached, we find an allowable load of 9 pounds per square inch. In the case of a short life, the initial deformation should be added to the amount of uniform flow.

VIII. Flow and the Fusion Point

The flow diagram also may be used to define the fusion point of a material with scientific exactness. Taking the usual test cone as a criterion, the fusion point may be defined as the temperature at which the material will flow at the rate of 100% per hour under a stress of 1 pound per square inch. In the case of the electrical porcelain of Fig. 9, the fusion point under these conditions is definitely fixed at 1640°C. In a few cases this criterion for the fusion point has been defined clearly. The softening point of glass as measured by Littleton[8] is an example of this.

IX. Conclusions

It has been shown that the ceramic body of crystals and glass follows definite laws of flow which may be readily determined in the ranges applying to service conditions. The flow fields outside of this range still remain to be explored in detail. Two equations connect the stress, temperature, and flow rate in the plastic field as follows:

$$V = k_1 F^a \text{ (for constant temperature)}$$

and

$$t = k_2 \log F + b \text{ (for constant rate of flow)}$$

Where t = temperature
V = flow rate
F = stress
a, b, k_1, and k_2 = constants

If these constants are determined for a number of materials and are shown to hold over a sufficiently large field, a few experimental determinations of flow rates will permit a complete evaluation of any particular material.

The heat treatment of the material has a profound influence on the flow characteristics. It is believed that much can be done to produce more suitable body structures by carefully controlled heating and cooling schedules.

Massachusetts Institute of Technology
Cambridge, Massachusetts

[8] J. T. Littleton, Jr., "Method for Measuring Softening Point of Glass," *Jour. Amer. Ceram. Soc.*, 10 [4] 259–63 (1927).

THE USE OF PYROPHYLLITE IN WALL-TILE BODIES*

By Ira E. Sproat

Abstract

The use of pyrophyllite in tile bodies is discussed. A statement of the place and character of the geological formation is made. The properties and thermal reactions of pyrophyllite are stated. The advantages gained by the use of pyrophyllite are decreased crazing, increased firing range, less fire-cracking, less warpage, and less die wear. Data and literature citations are given.

I. Introduction

More than a decade ago, a series of preliminary tests was made to determine the possibilities of pyrophyllite in whiteware bodies. It was concluded that this material was probably best suited for wall-tile bodies. As a result, the major portion of the research work since that time has been on this type of body.

Satisfactory wall tile have been produced at decreased cost, at lower maturing temperatures, with less shrinkage, decreased tendency to warp and fire-crack, increased range of maturing temperatures, decreased moisture expansion, decreased crazing, and better production of glazed tile by the one-fire process.

II. Geology

While pyrophyllite seems to be rather widely distributed throughout the world, the number of commercial deposits is limited.

Note: Mellor[1] reports that in 1829 R. Herman tested a sample of what was supposed to be talc from the Urals and showed that it was really an aluminum silicate which he designated "pyrophyllite," derived from the Greek words "pur" (meaning "fire") and "phullon" ("a leaf"), in allusion to the effect of heat in causing separation of the laminas in foliated varieties. The exact date of the discovery of pyrophyllite in the United States is somewhat in doubt, but it is generally assumed that the talc and soapstone deposits mentioned by Olmstead[2] in 1825 in his report on the slate belt of North Carolina are known today as pyrophyllite.

The principal deposits of pyrophyllite in the United States are in Moore and Chatham Counties in North Carolina, but it occurs also at Chesterfield, Chesterfield County, South Carolina; at Graves Mountain, Lincoln County, Georgia; at Staley, Randolph County, North Carolina; at Troy, Montgomery County, North Carolina; and in California.

The pyrophyllite deposits of North Carolina[3] occur in irregular, oval, or lens-like form in metamorphic rocks. The width of the bodies varies from 100 to 500 feet and the length from 700 to 1500 feet parallel to the strike. The maximum depth of the deposits is not known. The deposit at Hemp has been drilled to the depth of over 300 feet without reaching the bottom. Usually only about 50 to 150 feet of the center of the ore body is worked because the outer portions contain too many impurities.

Quartz, sericite, and pyrite are the only impurities that occur in sufficient quantity in the main body of the ore to be considered. Most of the quartz can readily be removed by hand sorting, and the pyrite can be removed partly by air separation and almost completely by electromagnets. Sericite occurs disseminated through the pyrophyllite in small scales and flakes. These flakes are nearly always so thin that they can not be recognized in the crude ore, but when fired to about cone 13 they show up as tiny vitreous gray bands.

Two deposits are being worked at present; one is located about one mile north of Glendon, and the largest and most important development is about two miles southwest of Hemp. The pyrophyllite used throughout this investigation came from the mines of the Standard Mineral Company, Hemp, N. C. This deposit is over 1200 feet long and the width of satisfactory ore is 30 to 150 feet. The ore body dips at an angle of from 75 to 45 degrees northwest.

While the deposit at Hemp has been worked steadily for a number of years, the amount of reserve ore is still very large. Core drilling of the

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[1] J. W. Mellor, A Comprehensive Treatise on Inorganic Chemistry, Vol. 6, page 498.

[2] D. Olmstead, Report on the Geology of North Carolina, 1825–27

[3] J. L. Stuckey, "The Pyrophyllite Deposits of North Carolina," N. Car. Dept. of Conservation and Development *Bull.*, No. 37, page 35; *Ceram. Abs.*, **10** [5] 188 (1927).

deposit to a depth of over 300 feet has blocked out over 1,500,000 tons of ore suitable for ceramic purposes. As a matter of fact the ore is freer from impurities at the lower levels.

At present, the pyrophyllite at Hemp is being mined for ceramic use at about 183 feet, brought to the surface, hand-selected, crushed, and ground to a fineness of 99% through a 150-mesh screen and not over 4% on a 200-mesh sieve. The sizing is done by Gayco air separators, which in turn remove some of the impurities left in the ore after being hand-selected.

III. Properties of Pyrophyllite

(1) Composition

Pyrophyllite is a crystalline mineral belonging to the rhombic or monoclinic system. It is a hydrous aluminum silicate having the following formula: $Al_2O_3 \cdot 4SiO_2 \cdot H_2O$, ($Al_2O_3$ 28.3%, $4SiO_2$ 66.7%, H_2O 5.0%). The material used in this investigation had the following chemical composition:

SiO_2	70.15%	K_2O	0.20%
Al_2O_3	23.84	Na_2O	1.54
CaO	0.06	Fe_2O_3	0.07
MgO	0.02	Ignition loss	4.00

(2) General Appearance

Pyrophyllite is a very soft mineral resembling talc, usually occurring in white, pale green-yellow, or light gray compact or foliated masses and occasionally as radial fibrous aggregates. It is more or less translucent. It is greasy to the touch and has a dull mat or pearly luster.

(3) Thermal Reactions

Houldsworth and Cobb[4] give the following results of thermal reactions: (*a*) slight endothermal reaction at 480°C, and (*b*) marked irreversible endothermal reaction between 720° and 830°C, quite distinct from those in the clay curves.

(4) Thermal Expansion Compared with Other Body Materials

From a study of the curves in Fig. 1 it will be noted that the thermal expansion of pyrophyllite is about the same as clay but far below that of flint and feldspar. When introduced into a ceramic body as a substitute for a part or all of the flint or feldspar, pyrophyllite causes a decrease in the thermal expansion of the body with the resulting decrease in the tendency of both body and glaze to fail when subjected to sudden temperature changes.

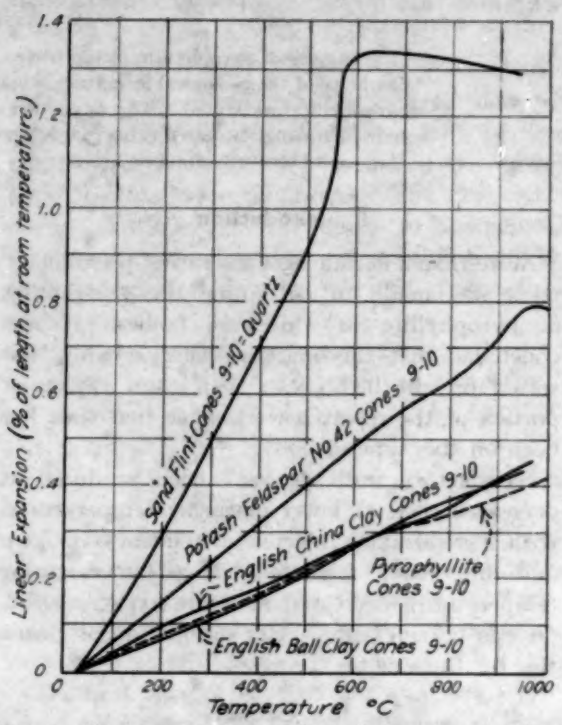

FIG. 1.—Linear thermal expansions of the common whiteware body constituents compared with pyrophyllite.

(5) Moisture Expansion after Firing at Cones 8 and 12

The expansion of pyrophyllite and of typical

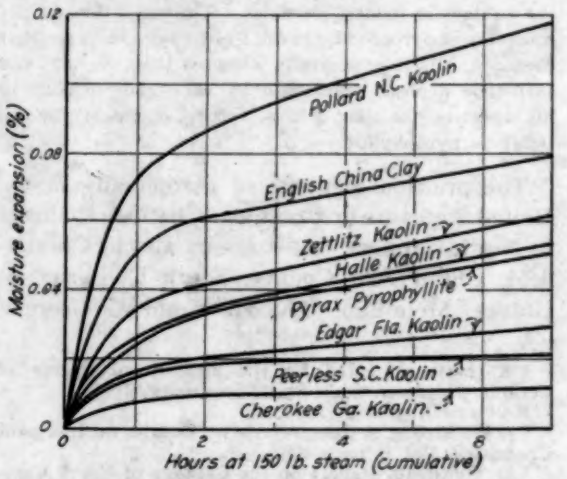

FIG. 2.—Moisture expansion of kaolins (cones 7 and 8).

[4] H. S. Houldsworth and J. W. Cobb, "The Behaviour of Fire Clays, Bauxite, etc., on Heating," *Trans. Ceram. Soc.* [Eng.], **22**, 111–37 (1922–1923).

china clays, after being fired to cones 8 and 12, is shown in Figs. 2 and 3. The moisture expansion of pyrophyllite is less than that of typical primary

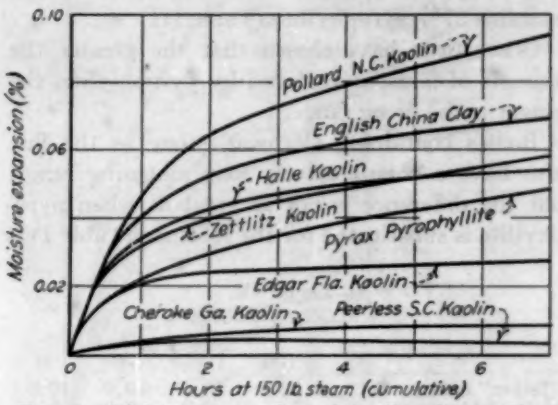

FIG. 3.—Moisture expansion of kaolins (cone 12).

kaolins but more than the secondary kaolins of South Carolina, Georgia, and Florida.

(6) Expansion and Shrinkage under Heat Treatment

One of the chief characteristic properties of pyrophyllite is its expansion when heated above 1300°F. The amount of expansion varies with different varieties of pyrophyllite. Expansions of 50% have been reported.

The volume expansion of the pyrophyllite from Hemp, N. C., is as follows:

Heat treatment (cones)	Volume expansion of original volume (%)	Heat treatment (cones)	Volume expansion of original volume (%)
020	0.0	04	15.0
018	6.5	02	14.5
016	11.1	1	13.6
014	13.9	3	12.9
012	15.0	5	11.8
010	15.4	7	10.5
06	15.5	10	9.0
		13	7.1

IV. Uniformity of Shipments of Pyrophyllite

Samples were taken from shipments made during 1927, 1928, 1929, 1930, and 1931 and were introduced into a standard body. The standard body used was as follows: pyrophyllite 50%, Kentucky-Tennessee Clay Co. No. 4 ball clay 30%, and "Cherokee" Georgia kaolin 20%.

The bodies were prepared in the usual way, dried at 100°C, 12% of water added, ground in a dust mill, and pressed into 4- by 2-inch tile on a hand-operated screw press. The trials were fired at cones 8, 10, and 12, and the absorptions and shrinkages were determined. The results are given in Table I.

TABLE I

UNIFORMITY OF PYROPHYLLITE SHIPMENTS

Cone No.	A	B	C	D	E
	Absorption of dry weight (%)				
8	13.6	13.2	13.3	13.5	13.5
10	12.4	11.6	11.7	12.4	12.5
12	9.0	8.9	8.9	9.4	8.6
	Total shrinkage of green length (%)				
8	2.4	2.5	2.5	2.0	2.3
10	3.0	3.0	3.2	2.6	3.0
12	4.6	4.6	4.8	3.5	4.4

Description of Samples

A, composite sample from cars shipped on Aug. 20, Sept. 15, Sept. 29, Oct. 18, and Nov. 23, 1927.
B, composite sample from cars shipped on June 6, June 26, July 17, July 20, and Aug. 3, 1928.
C, composite sample from cars shipped on March 22, April 18, May 14, June 2, June 8, and June 22, 1929.
D, composite sample from cars shipped on April 16, June 5, June 13, July 23, and Aug. 1, 1930.
E, standard sample received from mines June, 1931.

TABLE II

EFFECT OF FINENESS OF THE PYROPHYLLITE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Screen analysis in per cent of dry weight						
Remaining on 120-mesh sieve	0.00	0.05	0.20	0.25	0.60	0.55	1.50
Through: 120- and on 140-mesh sieve	0.00	0.10	0.30	0.30	0.80	0.80	1.80
140- and on 160-mesh sieve	0.00	0.15	0.45	0.50	1.75	1.65	3.20
160- and on 180-mesh sieve	0.15	0.25	0.70	0.70	3.00	2.90	4.80
180- and on 200-mesh sieve	0.25	0.70	2.40	2.70	7.00	7.70	11.75

Cone No.	Absorption of straight pyrophyllite in per cent of dry weight						
6	28.2	26.5	26.6	26.5	26.2	25.4	26.8
8	23.0	22.1	21.1	22.9	23.6	23.0	25.5
9	20.5	21.7	19.8	22.6	22.6	23.8	25.7
10	20.5	19.4	16.4	21.5	21.9	20.2	24.4
11	19.5	19.1	16.6	21.3	21.8	18.7	24.4

Cone No.	Total shrinkage of straight pyrophyllite in per cent of green length			
6	Expanded			
8	"			
9	"			
10	0.6	0.5	0.7	Expanded
11	0.7	0.6	1.3	"

TESTS OF PYROPHYLLITE SAMPLES INTRODUCED INTO STANDARD BODY

Cone No.	Absorption of dry weight (%)						
6	17.6	18.7	17.8	17.4	17.5	16.9	17.0
8	15.2	15.1	15.0	14.8	15.0	15.0	14.7
9	15.5	15.2	14.3	14.7	14.4	14.5	14.3
10	14.4	14.5	14.1	14.3	14.1	14.0	14.6
11	14.5	14.4	14.0	14.5	14.4	13.3	13.8

Cone No.	Total shrinkage of green length (%)						
6	1.6	0.9	1.0	1.0	0.6	0.9	0.5
8	2.7	2.6	2.4	2.1	1.9	2.1	1.8
9	2.8	2.6	2.4	2.1	2.0	2.4	2.1
10	3.0	2.9	2.8	2.4	2.2	2.4	2.1
11	3.2	2.9	2.9	2.4	2.3	2.5	2.1

Extensive tests have shown that pyrophyllite can vary considerably in fineness of grinding without affecting either the absorption or shrinkage of the body in which it is used (Table II). It was found, however, that if pyrophyllite was ground too fine it would not wet well and had a tendency to float in the blungers. As a result, it is now ground for the ceramic trade to the standard specifications for flint and feldspar.

V. Advantages of Pyrophyllite in Wall-Tile Bodies

A ten-year study of the use of pyrophyllite, both in the factory and laboratory, has proved that this new ceramic material when properly used in a tile body will (1) increase the maturing or firing range of the body, (2) decrease crazing due to thermal shock or moisture expansion or both, (3) decrease fire-cracking, (4) decrease the shrinkage with the resulting decreased warpage, and (5) decrease die wear.

(1) Increased Firing Range

Pyrophyllite substituted for flint and feldspar in a typical tile body greatly increases the maturing range of the body and gives uniform shrinkage over a wide range of temperature. Body 8, containing no pyrophyllite, has an absorption variation of 9.8% from cones 5 to 12 and a variation in shrinkage of 4.8%, while body 9, containing pyrophyllite, has a difference of only 3.0% in absorption and 1.6% in shrinkage. Body 10, containing no pyrophyllite, has a much shorter firing range than body 11, which is similar in composition but contains 37% pyrophyllite (Table III).

Other tests have shown that the greater the amount of feldspar replaced by pyrophyllite, the longer is the firing range.

Bodies containing Cornwall stone as the flux also have a comparatively long maturing range, but the difference is not as great as when pyrophyllite is substituted for the feldspar (Table IV).

TABLE III
WALL-TILE BODIES

	Composition (%) (8)	(9)	(10)	(11)
"Jasper" flint	33.0	10.0	33.0	10.0
Maine feldspar	12.0	3.0	10.0	4.0
"Cherokee" Ga. kaolin			15.0	15.0
Ky.-Tenn. Clay Co. No. 4 ball clay	27.0	27.0	27.0	27.0
Pollard N. C. kaolin	13.0	13.0		
Edgar E.P.K. Fla. kaolin	15.0	15.0	15.0	7.0
"Pyrax" pyrophyllite		32.0		37.0
Cone No.	**Absorption in per cent of dry weight**			
5	17.5	17.9	17.4	17.4
6	16.3	17.5	15.8	16.2
7	13.2	17.4	15.4	16.6
8	11.5	17.1	14.5	16.6
9	10.2	16.8	13.8	16.1
10	9.7	16.2	12.1	15.8
12	7.7	14.9	9.7	14.9
Cone No.	**Total shrinkage in per cent of green length**			
5	3.6	2.4	3.5	1.9
6	4.3	2.6	4.1	2.2
7	5.7	3.0	4.3	2.3
8	6.5	3.0	4.6	2.4
9	6.9	3.2	5.0	2.4
10	7.2	3.4	5.2	2.8
12	8.4	4.0	6.6	3.0

TABLE IV
WALL-TILE BODIES

	Composition (%) (12)	(13)	(14)	(15)
"Jasper" flint	32.0	33.0	10.0	10.0
Maine feldspar		2.0	2.0	2.0
Ky.-Tenn. Clay Co. No. 4 ball clay	30.0	21.0	30.0	
"Cherokee" Ga. kaolin			20.0	20.0
Cornwall stone	12.0	11.0		
Edgar E.P.K. Fla. kaolin	26.0	17.0		
Pollard N. C. kaolin		16.0		
"Pyrax" pyrophyllite			38.0	34.0
Ky.-Tenn. Clay Co. No. 12 ball clay				30.0
A-1 Canadian talc				4.0
Cone No.	**Absorption in per cent of dry weight**			
5	18.5	18.1	17.4	19.9
6	17.5	16.9	17.1	19.0
7	17.2	16.2	17.2	19.0
8	17.2	16.2	17.1	18.6
9	15.5	14.6	16.2	17.0
10	15.1	13.8	15.7	17.0
11	14.8	13.3	15.5	17.3
12	12.4	10.5	15.1	15.7
Cone No.	**Total shrinkage in per cent of green length**			
5	3.3	2.9	1.9	1.9
6	3.7	3.6	2.1	2.1
7	3.7	3.7	2.0	2.2
8	3.7	3.8	2.1	2.2
9	4.4	4.8	2.5	2.8
10	4.5	4.8	2.5	2.8
11	4.4	4.9	2.6	2.8
12	5.5	6.0	3.0	3.2

VI. Decreased Crazing Due to Moisture Expansion

Bodies I, D, F, B, A, and C of Fig. 4 are clay-feldspar-flint wall-tile bodies; body E contains about 20% pyrophyllite, and body G is a typical high pyrophyllite body. Body H is a high talc (75%) body which is guaranteed not to craze in service. The interesting feature of these curves is the very low moisture expansion of bodies H and G. Both bodies are in plant production with marked success. Tile is being made of body H by the one-fire process.

The effect of pyrophyllite on moisture expansion is plainly shown in Table V and Fig. 5.

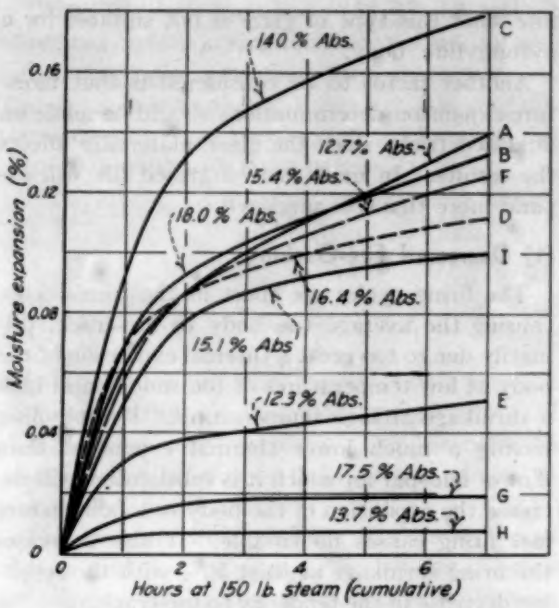

FIG. 4.—Moisture expansion of commercial wall tile.

NOTE: Curve *C* should read 14.0% Abs.

Bodies 18 and 19, although they contain whiting, have a longer firing range than bodies 16 and 17, which contain no whiting. In other words, there can be no question but what pyrophyllite will increase the firing range of clay-flint-feldspar or Cornwall stone bodies. This is quite marked in body 18 where the whiting is only 1.0%.

The low shrinkage of pyrophyllite bodies 18 and 19 is marked, being less than half that of bodies 16 and 17. Bodies 16 and 17, without pyrophyllite, have a moisture expansion four times as great as bodies 18 and 19 which contain 37 and 38% pyrophyllite.

This marked difference in moisture expansion is due (1) to the property of pyrophyllite to produce a low expansion in a body and (2) to the low percentage of feldspar necessary to produce vitrification. Geller and Creamer[5] have pointed out that fused feldspar is the greatest offender in producing a high moisture expansion in bodies; therefore, it should be eliminated or kept as low as possible.

Decrease in moisture expansion with the inevit-

[5] R. F. Geller and A. S. Creamer, " 'Moisture Expansion' of Ceramic Whiteware," *Bur. Stand. Jour. Research*, 9 [3] 291–307 (1932); R. P. 472; *Ceram. Abs.*, 11 [12] 622 (1922).

TABLE V
WALL-TILE BODIES

	Composition (%)			
	(16)	(17)	(18)	(19)
"Jasper" flint	37.0	32.0	15.0	15.0
Maine feldspar	9.0		3.0	3.0
Ky.-Tenn. Clay Co. No. 4 ball clay	20.0	30.0	18.0	18.0
Edgar Fla. kaolin	17.0	26.0		
Pollard N. C. kaolin	17.0			
"Cherokee" Ga. kaolin			18.0	18.0
"Pyrax" pyrophyllite			37.0	38.0
"Ceramicite" talc			4.0	4.0
Cornwall stone		12.0		
Imported whiting			1.0	3.0
Calif. magnesite			4.0	1.0
Cone No.	**Absorption in per cent of dry weight**			
2	19.3	19.3	18.4	17.4
4	18.8	18.4	17.4	16.8
5	18.7	17.8	17.0	16.0
6	17.6	17.3	16.6	15.8
7	15.9	16.5	15.5	15.7
8	14.5	16.0	15.5	15.3
9	13.0	15.6	15.6	14.9
11	11.5	13.7	15.2	11.0
Cone No.	**Total shrinkage in per cent of green length**			
2	2.1	3.0	1.3	0.9
4	2.5	3.2	1.5	0.9
5	2.8	3.6	1.6	1.2
6	2.9	3.7	1.7	1.2
7	3.7	4.0	1.7	1.2
8	3.9	4.1	1.6	1.4
9	5.2	4.4	1.6	1.8
11	5.5	5.1	1.7	3.0
	Moisture expansion in per cent of orginal length (cone 9)			
1 hr. at 150 lb.	0.055	0.066	0.012	0.016
3 hr. at 150 lb.	.080	.091	.018	.022
5 hr. at 150 lb.	.094	.108	.020	.025
7 hr. at 150 lb.	.106	.117	.020	.025

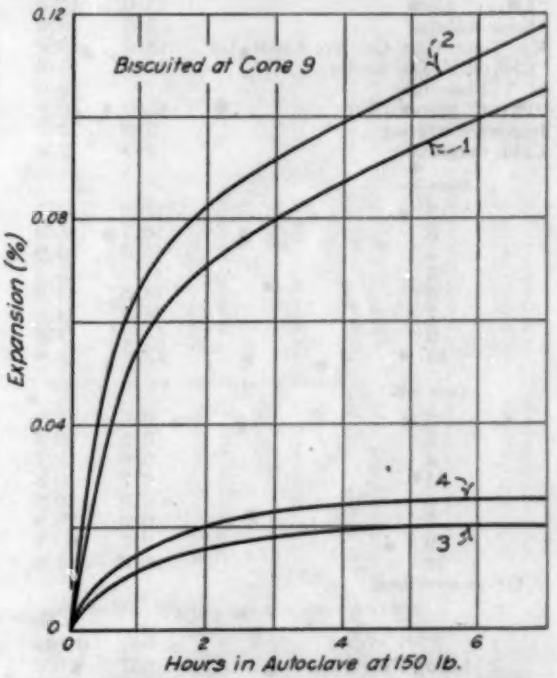

FIG. 5.—Effect of pyrophyllite on moisture expansion.

able decrease in crazing, providing the glaze fits the body, is interesting, not because of its complexity but because of its very simplicity. The solution appears obvious, but because of the varying results that have been obtained by investigators it is less obvious than it seems.

The writer's tests have proved that the only way to solve this problem is to develop a body with a moisture expansion of less than 0.03% and fit a glaze to it, *e.g.*, six tile each of bodies 16, 17, 18, and 19, after being biscuited at cone 9, were dipped in the following glaze and glost fired at cones 4 to 5.

Glaze composition

$$\left.\begin{matrix}0.018\ Na_2O\\0.396\ CaO\\0.185\ K_2O\\0.256\ PbO\\0.145\ ZnO\end{matrix}\right\}\ 0.237\ Al_2O_3\ \left\{\begin{matrix}2.484\ SiO_2\\0.364\ B_2O_3\end{matrix}\right.$$

While pyrophyllite bodies 18 and 19 showed less tendency to craze than bodies 16 and 17, the difference of only about three hours at 150 pounds in the autoclave is not great. Tile are being made with a moisture expansion of 0.03% and less which have not been crazed after 100 hours in the autoclave at 150 pounds. It is quite evident, therefore, that this type of glaze is not suitable for a pyrophyllite body.

Another factor to be considered is that moisture-expansion determinations should be made on unglazed trials, since the glaze materially affects the results. In most cases a glazed tile will expand more than the unglazed.

(1) Decreased Fire-Cracking

The firing cycles are short in the tunnel kiln, causing the average tile body to fire-crack, primarily due to too great a thermal expansion of the body at low temperatures or too sudden and high a shrinkage at high temperatures. Pyrophyllite, having a much lower thermal expansion than flint or feldspar for which it is substituted, will decrease the expansion of the body to a point where fast firing causes no trouble. It also decreases the firing shrinkage at least 50% with the resulting decrease in the tendency to fire-crack.

(2) Decreased Warpage

Decrease in warpage in the kilns will nearly always follow a decrease in the firing shrinkage Pyrophyllite greatly decreases shrinkage.

TABLE VI

WALL-TILE BODIES

	Composition (%)								
	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
"Jasper" flint	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Maine feldspar	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Ky.-Tenn. Clay Co. No. 4 ball clay	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
"Cherokee" Ga. kaolin	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
N. Y. State talc		5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0
"Pyrax" pyrophyllite	45.0	40.0	35.0	30.0	25.0	20.0	15.0	10.0	5.0
Imported whiting	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Calif. magnesite	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Cone No.	Absorption in per cent of dry weight								
2	17.6	17.7	17.2	17.4	17.5	17.6	17.1	17.6	17.9
3	16.7	16.9	16.3	16.5	16.8	17.0	16.8	16.9	17.2
4	15.0	15.9	15.7	15.7	16.1	16.5	16.5	16.3	16.6
5	14.6	15.4	15.2	15.1	15.6	15.7	15.8	15.1	13.8
6	14.5	14.9	14.9	15.0	15.0	15.4	14.8	13.8	9.9
7	14.5	14.9	14.8	15.1	14.9	15.3	14.2	12.5	0.7
9	14.2	14.8	14.8	14.5	15.0	13.3	7.5	0.0	0.0
10	13.8	13.6	13.1	13.1	13.0	2.1	0.0	0.0	0.0
Cone No.	Total shrinkage in per cent of green length								
2	0.0	0.1	0.5	0.6	0.7	1.0	1.3	1.4	1.6
3	0.2	0.3	0.6	0.8	0.8	1.1	1.4	1.5	1.7
4	0.6	0.7	0.7	0.9	0.8	1.2	1.5	1.6	1.8
5	0.7	0.8	0.7	0.9	0.8	1.2	1.6	1.7	2.0
6	0.8	0.8	0.7	0.9	0.9	1.3	1.7	1.9	2.1
7	0.9	0.9	0.8	0.9	0.9	1.3	1.8	3.1	8.7
9	0.9	0.9	0.7	0.8	1.0	1.4	3.7	OF	OF
10	1.0	1.0	1.0	1.1	1.1	.5.3	6.7	OF	OF
OF = overfired.									
	Moisture expansion in per cent of original length (cone 3 biscuit)								
1 hr. at 150 lb.	0.044	0.045	0.049	0.049	0.051	0.050	0.051	0.050	0.053
3 hr. at 150 lb.	.057	.057	.059	.059	.062	.063	.063	.063	.065
5 hr. at 150 lb.	.066	.066	.066	.066	.066	.067	.069	.068	.071

Thirty tile each from bodies 16, 17, 18, and 19 were fired under varying conditions of setting and firing, the trials being fired from cones 4 to 11. The average warpage of these test tile was determined as well as the average thickness of the tile. The results are given below.

Body No.	Av. thickness (in.)	Av. warpage (in.)
16	0.401	0.0069
17	.429	.0053
18	.334	.0022
19	.333	.0025

It is quite evident from the above data that the decreased shrinkage caused by pyrophyllite will also decrease the warpage. This decrease is quite marked in spite of the fact that bodies 18 and 19 were much thinner.

This freedom from warpage has made it possible to manufacture pyrophyllite tile by the one-fire process, and is also a decided advantage in producing 12-inch square or larger tile.

(3) Decreased Die Wear

The smooth and soft character of the pyrophyllite grains should decrease the die wear. One manufacturer of tile reports an increase of over 400% in the life of dies since changing to a pyrophyllite body. Another manufacturer reports no increase.

VII. Pyrophyllite vs. Talc in Wall-Tile Bodies

Absorption data in Table VI show that the firing range of this type of body is not materially affected by the talc until it is increased beyond 20%; with each additional increase, there is a decided decrease in the maturing range of the body. Bodies 23 and 24 had a marked tendency to stick together when fired above cone 9, in spite of an absorption of 13.0% at cone 10.

Substitution of talc for pyrophyllite tends to increase the shrinkage, but this increase is very small until the amount of talc exceeds 20%. This difference in shrinkage is largely due to the expansion of the pyrophyllite.

The data also seem to indicate that as the talc is increased at the expense of the pyrophyllite, the moisture expansion increases. The difference, however, is not great even though the tests were made on tile biscuited at cone 3. This low bis-

TABLE VII

WALL-TILE BODIES

	Composition (%)									
	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)
"Jasper" flint	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	10.0
Maine feldspar	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
"Cherokee" Ga. kaolin	18.0	18.0	18.0	18.0	18.0	18.0	18.0	13.0	18.0	18.0
Ky.-Tenn. Clay Co. No. 4 ball clay	18.0	17.0	16.0	15.0	14.0	13.0	12.0	18.0	18.0	18.0
"Pyrax" pyrophyllite	41.0	41.0	41.0	41.0	41.0	41.0	41.0	36.0	41.0	41.0
N. Y. State talc	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Imported whiting		1.0	2.0	3.0	4.0	5.0	6.0	5.0	5.0	5.0
Calif. magnesite	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cone No.	Absorption in per cent of dry weight									
4	16.4	16.6	17.2	18.3	18.8	19.5	19.9	18.9	18.9	18.9
5	15.8	16.1	16.8	18.1	18.3	19.0	19.4	18.9	18.2	18.4
6	15.4	15.5	16.1	17.1	17.8	18.0	18.3	18.5	17.5	17.4
7	15.0	14.9	15.7	16.7	16.8	17.7	18.1	17.0	16.9	17.0
8	14.4	14.4	15.6	16.0	16.3	16.5	16.8	16.5	16.0	15.8
9	14.2	14.3	15.4	15.2	14.9	14.5	13.1	14.2	14.5	14.0
10	14.0	14.1	14.5	13.9	10.8	10.4	3.2	8.5	8.5	6.3
11	14.0	14.0	14.7	13.2	10.2	0.8	1.7	2.7	3.3	2.6
Cone No.	Total shrinkage in per cent of green length									
4	1.2	1.0	0.8	0.6	0.2	0.0	E0.1	0.4	0.2	0.4
5	1.3	1.2	0.9	0.7	0.3	0.1	0.0	0.5	0.3	0.6
6	1.5	1.4	1.2	0.9	0.5	0.3	0.3	0.8	0.9	0.9
7	1.6	1.4	1.2	1.0	0.6	0.4	0.4	0.9	1.1	1.4
8	1.5	1.4	1.2	1.0	0.8	0.7	1.2	1.0	1.2	2.1
9	1.6	1.5	1.3	1.1	1.4	1.2	2.6	2.4	2.1	3.1
10	1.7	1.6	1.4	1.5	3.1	3.5	5.9	4.7	5.3	5.5
11	1.9	1.7	1.6	2.0	3.3	6.5	6.7	6.0	5.8	6.1
E = expansion.										
	Moisture expansion in per cent of original length (cone 8 biscuit)									
1 hr. at 150 lb.	0.025	0.021	0.021	0.020	0.021	0.024	0.025	0.022	0.024	0.017
3 hr. at 150 lb.	.035	.024	.024	.024	.026	.028	.029	.026	.029	.021
5 hr. at 150 lb.	.040	.027	.024	.026	.028	.031	.033	.029	.032	.023

cuit temperature was used to obtain as uniform a porosity as possible for all bodies and the maximum variation in moisture expansion.

By comparing bodies 21 with 18 in Table V, which are similar in composition, it will be observed that the moisture expansion is greatly decreased in this type of body by increased firing temperature without any marked difference in porosity. This has been noted in other tests, and the rather limited data seem to indicate that the firing temperature influences the moisture expansion more than the porosity of a given body.

The color of the tile in this series ranged from a good white, to cream-white, tan, and gray. The whiteness of the tile decreased with every increase in the talc content. Body 20 has the best color and 28 the poorest. However, when the tile are fired at cone 4 or lower, bodies 21 to 24 have a fair cream-white color.

Bodies containing more than 15% talc had a marked tendency to absorb the glaze. This absorption increases with every increase in talc, which means that special glazes, high in alumina, would have to be developed for these high talc bodies.

VIII. Effect of Whiting on Pyrophyllite-Tile Bodies

Data in Table VII show that the firing range is not materially affected until the whiting exceeds 3.0% and with every further increase the range is decreased. The moisture expansion is decreased by the addition of 1.0 to 3% of whiting. Further additions of whiting increase the moisture expansion; therefore, the data indicate that from 1 to 2% of whiting should be used in this type of body if minimum expansion is desired.

Small additions (less than 4%) of whiting did not affect the color to any extent but greater amounts imparted a decided cream color to the body.

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New York, N. Y.

THE EFFECT OF ALUMINA UPON THE CHEMICAL DURABILITY OF SAND-SODA-LIME GLASSES*

By A. K. Lyle, William Horak, and Donald E. Sharp

Abstract

The chemical durabilities of 25 glasses, with and without alumina, were determined by a powder method. From the data obtained a formula was derived for calculating the chemical durability of sand-soda-lime glasses containing alumina. The introduction of 1.5 to 2.5% alumina improves the chemical durability, the greatest benefit occurring when the alumina is one-eighth the soda content.

I. Introduction

The chemical durability of glass has been the subject of many investigations, a number of which have dealt with the effect of particular glass constituents. Among these, alumina has often been discussed and its beneficial effect upon the durability of glass has long been recognized. In many of the investigations, however, the glasses studied have been in a rather narrow range of composition, or else the compositions were sufficiently complicated to mask the specific effect of alumina. The conclusions drawn in most cases, moreover, have been confined to general statements to the effect that additions of alumina to a glass improve its chemical durability. There has been little indication as to what is the best amount of alumina to use or what substitutions are advisable.

(1) Object of Study

In this study it was planned to discover the effect of various alumina substitutions upon the chemical durability of the full range of what might be considered commercial glasses of the simple sand-soda-lime type. The problem was consequently divided into two distinct parts, (1) the chemical durability relations of the simple sand-soda-lime glasses containing the usual small amounts of alumina and other minor impurities, and (2) the chemical durability-composition relations of the sand-soda-lime-alumina glasses.

II. Preparation of Glasses

In all, forty glasses were prepared, but only

* Received October 30, 1935.

twenty-five of these were actually used in the calculations. The other fifteen were somewhat lacking in homogeneity and consequently were unsuited for durability measurements. The batch materials used consisted of the ordinary commercial glass sand of a low iron content, soda-ash, and a good grade of limestone. Meltings were carried out in a Fletcher-type furnace in pots holding about 25 pounds of glass. The pots* were specially made of a sillimanite type of material.

By stirring the glass at intervals during the melting period, a fair degree of homogeneity was obtained. The glasses were by no means of optical quality but were judged to be at least as homogeneous and free from defects as ordinary bottle glass melted in continuous tanks. The melting time averaged ten hours at a temperature of 1400°C. All of the glasses were cast in sheets about $\frac{1}{2}$ inch thick and were annealed before testing.

The compositions of the glasses were determined by analysis. Standard routine methods were employed, involving double dehydration of the silica and subsequent determination of R_2O_3, CaO, and MgO. The alkali was taken by difference. Owing to the importance of the alkali in relation to chemical durability, it might have been better to determine the soda content directly, but from past experience it is certain that the results by difference cannot be far wrong, so that there can be no serious objection to the method employed. The total R_2O_3 was counted as alumina because of the low iron content of the glass, which was less than 0.1% and practically constant. All of the glasses contained 0.1% magnesia, or less, which percentage was added to the lime.

III. Method of Testing

For testing the chemical durability, a powder or grain method was selected, using water as the attacking medium. In this connection, it is realized that there is no accelerated test of chemical durability to which there are not some objections. Accordingly no claim is made that the method is necessarily a true index of durability, although it certainly is at least an approximation to such an index. A ten-gram sample of 35- to 48-mesh grains in contact with 100 milliliters of distilled water, contained in a 250-milliliter Erlenmeyer Pyrex brand flask, was held at a temperature of 90°C for four hours. The resulting solution was cooled and titrated against $N/50$ sulfuric acid using methyl red as the indicator. The number of milliliters of acid required for titration was taken as the measure of chemical durability. There did not seem to be any advantage in calculating the results to percentage Na_2O extracted or in estimating the surface area of grains since, in general, such calculations merely serve to mask the original data or to change the magnitude of the figures representing the measurements. Check results indicated that the method was reproducible to within 10% of the titration value. It is, of course, understood that the results really express the amount of alkali extracted so that the larger the titration value, the less the chemical durability of the glass.

In connection with the testing, it should be mentioned that the homogeneity of the glass is extremely important. Lack of homogeneity invariably leads to high results. This feature was shown in a number of the preliminary trials with glasses not melted according to the standard procedure, so that care was taken to include only data on glasses that were reasonably homogeneous.

IV. Tests of Sand-Soda-Lime Glasses

The group of compositions classed as sand-soda-lime glasses is shown in Table I. The R_2O_3 (alumina) content of these glasses averages 0.7% ± 0.1%, glass No. 4 with 0.4% R_2O_3 being the only exception. As mentioned previously

TABLE I

SAND-SODA-LIME GLASSES

Melt No.	SiO_2	CaO	Na_2O	R_2O_3	$Na_2O + Al_2O_3$	Chemical durability $N/50$ acid (ml.) Observed	Chemical durability $N/50$ acid (ml.) Calculated
90G	72.5	13.2	13.7	0.6	14.3	3.2	3.3
4	72.7	13.2	13.7	0.4	14.1	4.1	4.0
910	72.5	12.6	14.3	0.6	14.9	4.1	4.2
3809A	73.2	11.3	14.8	0.7	15.5	5.0	4.8
1A	70.4	14.1	14.7	0.8	15.5	5.2	4.4
2	72.5	11.2	15.6	0.7	16.3	6.0	6.5
3785A	73.6	9.2	16.4	0.8	17.2	9.5	8.2
2W	69.8	12.2	17.2	0.8	18.0	9.9	10.8
2A	69.7	12.4	17.1	0.8	17.9	10.9	10.4
3A	72.3	7.4	19.6	0.7	20.3	28.0	23.7
4A	69.8	8.5	20.9	0.8	21.7	37.5	32.2
X2	65.7	10.5	23.1	0.7	23.8	59.4	60.9

* Obtained from the Charles Taylor Sons Company and the Findlay Clay Products Company.

the small amount of magnesia present has been included with the calcium oxide.

With the glasses arranged in order of decreasing chemical durability (increasing acid titration) as they are in Table I, it is interesting but not surprising to note that they are also arranged in order of increasing alkali content. The increase in the acid titration with increase in soda is quite rapid, the logarithm of the titration figure being practically a linear function of the logarithm of the alkali content over the range of compositions studied. This relation of chemical durability to composition is shown in Fig. 1, in which all of the points fall on, or very near, the straight line. Although several other methods of representing the data were tried, the purely empirical representation by plotting on double log paper, proved to be the simplest and most useful.

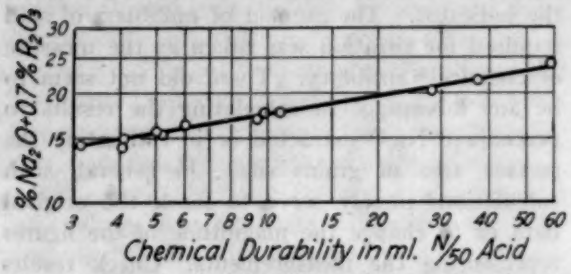

FIG. 1.—The chemical-durability relations of sand-soda-lime glasses.

It will be noted that the points shown in Fig. 1 are not merely the percentages of soda, but are the sums of the percentages of soda and alumina. The reason for this will appear later when the glasses containing higher alumina contents are discussed. For the moment, it is sufficient merely to point out that the straight-line relation in Fig. 1 represents the chemical durability-composition relations of some sand-soda-lime glasses containing 0.7% alumina as an impurity, and, for reasons that will appear later, that the alumina has been added to the alkali in plotting the points.

Since the points lie substantially on a straight line, the durability-composition relation for these glasses may be expressed by the formula,

$$\text{Log } D = a + b \log N \qquad (1)$$

Where D = chemical durability figure
N = % Na_2O + constant Al_2O_3
a and b are constants.

or

$$D = xN^b \qquad (2)$$

Where $\log x = a$ in (1).

In order to check this method of expressing the data, some of the results from glasses tested by Cauwood, Clarke, Muirhead, and Turner[1] have been plotted in Fig. 2(*a*). The five glass compositions selected contained from 13 to 21% soda and 0.6 to 0.7% R_2O_3. These glasses had been tested by five different methods, so it is particularly interesting to note that in every case the results may be expressed in terms of the soda content of the glasses and, furthermore, that in the range of 16 to 21% alkali, the straight-line log-log relation also holds. That the straight-line relation does not hold for lower soda contents may be due to the manner of testing, Cauwood and his co-workers having used cast disks instead of freshly fractured grains for the test sample.

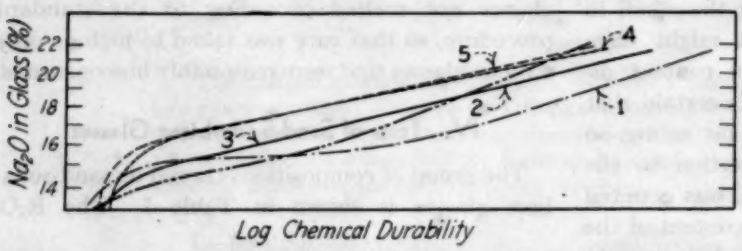

FIG. 2(*a*).—The chemical durability of sand-soda-lime glasses from data by Cauwood, Clarke, Muirhead, and Turner, plotted as a function of the soda content.

Attacking medium
(1) HCl constant boiling
(2) NaOH 2*N*
(3) Na_2CO_3 2*N*
(4) and (5) water

More recent studies by Turner[2] serve as a further check on the method of plotting results. Figure 2(*b*) is the log-log graph of Turner's results from boiling water tests on five different glass compositions made to show the influence of composition. The glasses show a random composition variation, the silica ranging from 72 to 75%, the lime from 6.3 to 9.1%, and the soda from 18.8 to 15.5%, while the R_2O_3 is fairly constant at 0.5 or

[1] J. D. Cauwood, J. R. Clarke, C. M. M. Muirhead and W. E. S. Turner, "The Durability of Lime-Soda Glasses," *Jour. Soc. Glass Tech.*, **3** [12] 228–37 (1919).

[2] W. E. S. Turner, "Basis of a Standard Test for the Chemical Durability of Glass Bottles," *ibid.*, **19** [74] 171–88 (1935).

0.6%. Here again the straight-line relation between the logarithm of the soda content and the logarithm of the durability figure is shown to give an accurate representation of the data.

V. Durability a Function of Alkali Content

It is surprising to find that over the range of composition studied, the durability of sand-soda-lime glasses, as determined by a powder method, can be expressed in terms of the alkali content alone, without regard for the silica or lime percentages. In other words, the effects of silica and lime on the durability must be nearly equal in the range of compositions investigated.

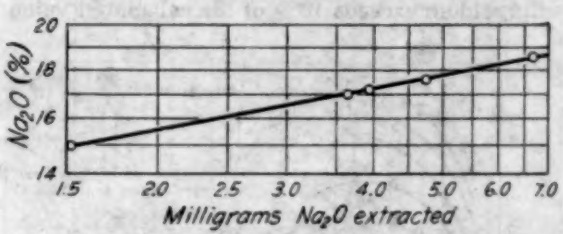

FIG. 2(*b*).—The chemical durability of sand-soda-lime glasses from data by Turner.

In further support of this conclusion, the works of Tielsch and Zschimmer[3] and of Möller and Zschimmer[4] also are worthy of note. Their investigations have shown a definite effect for lime displacing silica, but the difference in chemical durability between glass of 10% CaO and glass of 15% CaO is quite small, and data representing the two percentages overlap. The fact that their data were obtained on fire-polished samples may not make the results by the two methods strictly comparable, of course, but it seems evident that the actual amount of lime is relatively unimportant in the range between 8% and 14% CaO.

VI. Sand-Soda-Lime-Alumina Glasses

Table II gives the compositions of the glasses containing more than 1% alumina, the actual range being from 1% to nearly 7%. The soda content varied from 14% to nearly 21%, and the lime from 8 to 13%. This is nearly the full range of compositions used in bottle and window glasses. As in Table I the glasses are arranged in order of decreasing durability, but from mere examination of the results no simple relation is apparent.

It is readily noted that only in a general way is the quantity of alkali the determining factor, which suggests immediately that alumina differs entirely from silica and lime in its effect upon the chemical durability of a glass and, therefore, that it is necessary to express the durability in terms of the alumina as well as the soda content. Accordingly, since the chemical-durability relations of sand-soda-lime glasses can be expressed in terms of the soda content, the most logical method of showing the effect of alumina would be to consider the alumina as a substitute for soda. Thus glass 9 of Table II, which contains 2.5% alumina and 16.8% soda may be considered to be a glass of 19.3% Na_2O in which 2.5% Al_2O_3 has been substituted for soda.

In Fig. 3 all of the glasses of Table II have been plotted in terms of their alumina contents and durability values. By connecting these points with the points representing the durability of the corresponding sand-soda-lime glasses of 0.7% Al_2O_3, it was found that the slope of the lines was nearly constant for all alumina contents and that the substitution of alumina for soda resulted in a straight-line relation on log-log scales.

TABLE II

SAND-SODA-LIME-ALUMINA GLASSES

Melt No.	SiO_2	CaO	Na_2O	R_2O_3	$Na_2O + Al_2O_3$	Chemical durability $N/50$ acid (ml.) Observed	Chemical durability $N/50$ acid (ml.) Calculated
12	72.5	11.5	13.7	2.3	16.0	2.8	2.7
8	72.1	12.7	14.0	1.3	15.3	3.3	3.1
7	71.6	11.6	15.2	1.6	16.8	3.8	4.5
89E	71.9	11.2	15.1	1.8	16.9	4.4	4.4
10	71.4	10.2	16.0	2.4	18.4	6.0	6.0
9	71.9	8.8	16.8	2.5	19.3	7.1	7.1
3809AX	71.4	10.6	16.9	1.1	18.0	8.0	8.7
AX	71.4	10.7	16.9	1.0	17.9	8.1	9.0
3785B	71.2	9.3	17.0	2.5	19.5	8.4	8.2
3785C	69.3	9.3	16.9	4.5	21.4	9.8	9.6
3678	72.3	9.1	17.4	1.2	18.6	10.1	10.0
3679	72.6	8.3	17.3	1.8	19.1	10.2	9.0
3785D	68.5	8.7	16.4	6.4	22.8	11.8	11.1

[3] A. Tielsch and E. Zschimmer, "Changes in Alkaline Solubility of Fire-Polished Glasses by Firing Alkalis on the Surface of the Melt," *Sprechsaal*, **66** [17] 285–86; [18], 303–306; [19] 319–22; [20] 334–37 (1933); *Ceram. Abs.*, **12** [12] 417 (1933).

[4] W. Möller and E. Zschimmer, "Hot Alkaline Solubility of Fire-Polished Sodium-Lime-Silica Glasses as Function of the Chemical Composition," *Sprechsaal*, **62** [3] 38–39; [4] 57–60; [5] 79–82; [6] 94–95; [7] 115–16; [8] 133–34; [9] 150–54 (1929); *Ceram. Abs.*, **8** [7] 535 (1929).

Figure 3 is quite important since it represents completely the chemical durability-composition relations of the sand-soda-lime-alumina glasses within the scope of this investigation. Because the method of representation is not a common

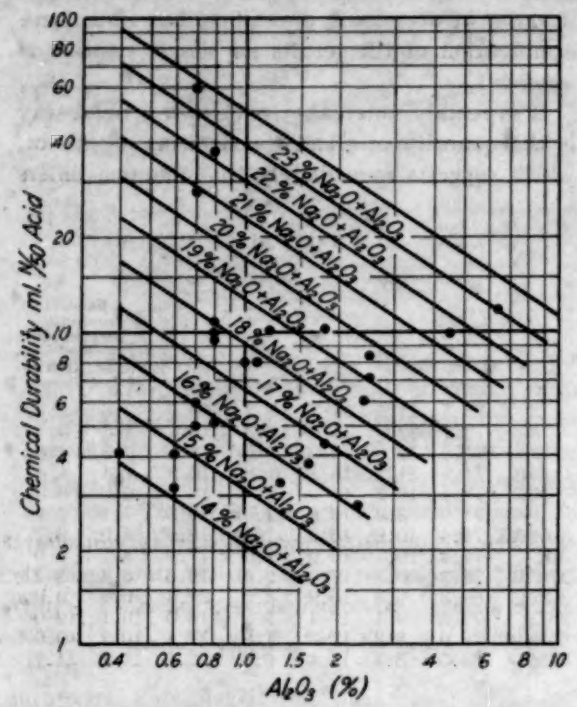

FIG. 3.—The chemical durability of all of the glasses tested in terms of their soda and alumina contents.

one and because the specific effect of alumina is not readily seen, a detailed explanation of Fig. 3 is needed.

The method of reading the graph can best be explained by giving an example. To find the chemical durability first add the soda and alumina percentages. Thus in a glass of 17.5% soda and 0.5% alumina, the total R_2O_3 plus Na_2O is 18%. The chemical durability of this glass will lie on the line marked 18. At 0.5% R_2O_3 on the 18% soda line, the durability figure is 14.3 milliliters $N/50$ acid.

If 1.0% Al_2O_3 is substituted for lime in the above glass, it will then contain 1.5% alumina and 17.5% soda. The total R_2O_3 plus Na_2O is now 19% so that the durability of the glass will be located on the 19% line. At 1.5% alumina on the 19% line the durability figure is 9.6 milliliters $N/50$ acid.

The data from Fig. 3 can be represented by the formula:

$$\text{Log } D = a + b \log (N + A) + c \log A$$

Where D = the durability figure
N = percentage of Na_2O
A = percentage of Al_2O_3
a, b, and c are constants.

Using the exact data from the investigation, this equation becomes

$$\text{Log } D = -6.427 + 5.89 \log (N + A) - 0.654 \log A$$

or

$$D = \frac{(N + A)^{5.89}}{10^{6.427} A^{0.654}}$$

The values for chemical durability calculated from this equation are shown in the last column of Tables I and II where it may be seen that the difference between calculated and observed results seldom exceeds 10% of the calculated value.

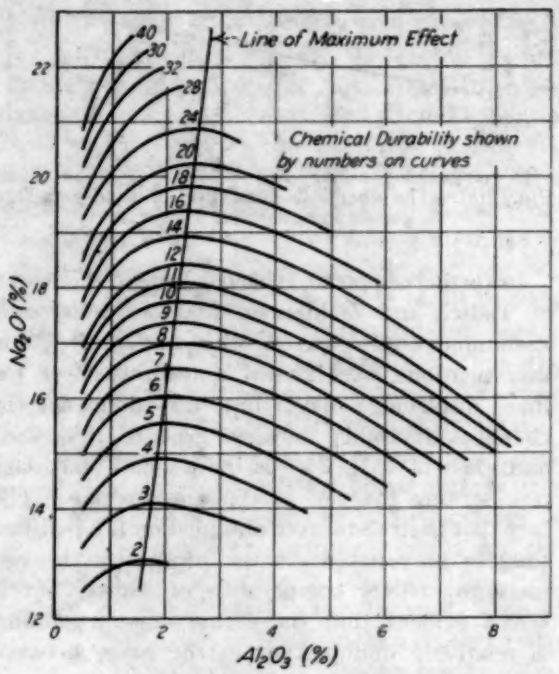

FIG. 4.—The chemical durability of sand-soda-lime glasses showing the line of maximum alumina effect.

The complete range of glasses is also represented by Fig. 4, in which the effect of alumina is brought out more clearly. In using this figure the percentages of soda and alumina are taken directly from the coördinates, and the durability for any given composition is indicated by the number on each curve. These numbers refer to the amount of alkali extracted from the glass and, therefore, the lower the number, the greater the chemical durability, or resistance to attack, of the glass.

In Fig. 4, it is apparent that the chemical durability increases with an increase in alumina content until a maximum is reached. As the alumina content is increased beyond the point of maximum effect, the increase in chemical durability will not be so great. By calculation it can be shown that alumina exhibits the greatest

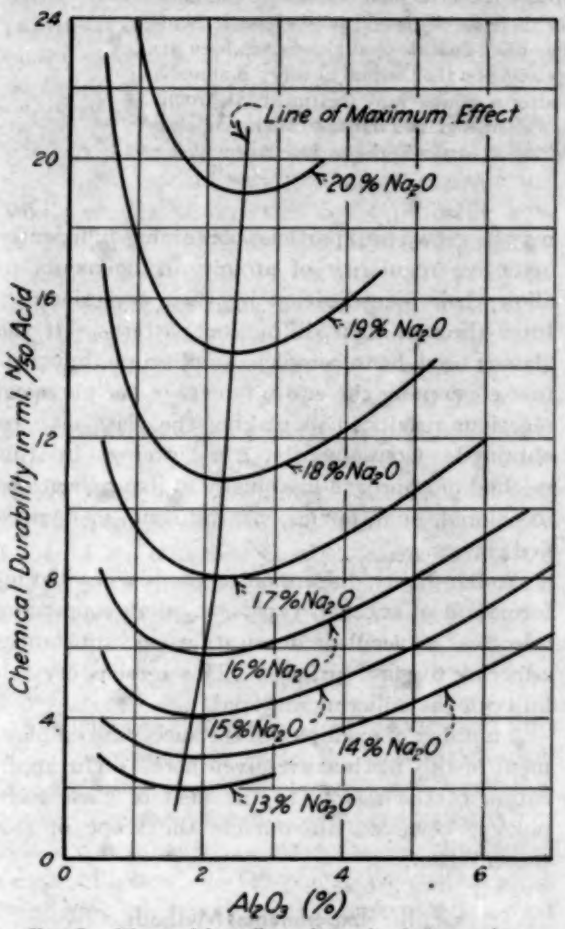

FIG. 5.—The positive effect of alumina in increasing chemical durability.

improvement in chemical durability when the amount is one-eighth the alkali content of the glass. This is shown in Fig. 4 by the line marked "maximum effect." For example, a sand-soda-lime glass containing 17.0% soda has a maximum chemical durability if it also contains 2.1% alumina. At 14.0% soda the maximum alumina effect is shown at 1.75% alumina. This relation of alumina and soda, however, should not be interpreted as defining the exact percentage of alumina that should be used. Larger amounts of alumina may be used without any great detriment to the chemical durability and with possible advantage in working or melting properties.

The positive effect of alumina is indicated in Fig. 5 which shows that the addition of alumina in a sand-soda-lime glass always improves the resistance to solution independent of the manner of substitution. Indeed, it is possible to increase the alkali content of a glass and, by the substitution of alumina for lime or silica, to keep the durability unchanged. The following two compositions would yield identical durability figures in spite of the 1.0% difference in soda content:

	No. 1	No. 2
Silica	73.5%	73.5%
Alumina	0.6	2.2
Calcia	9.9	7.3
Soda	16.0	17.0
Durability figures	8.0	8.0

This feature of the action of alumina allows for changes in the working properties of a glass without affecting its performance in service.

VII. Summary

Further examination of the data yields some additional information which may be considered to summarize the effects of alumina upon the chemical durability of glass. Since the problem of improving chemical durability also implies the necessity of keeping the working properties of a glass practically unchanged, it is interesting to note what decrease in soda content is necessary to equal a 1.0% addition of alumina. Over most of the range of compositions the decrease in soda would have to be 1.0%. This means that a glass of 17% soda and 1.5% alumina is equal in resistance to chemical attack to a glass of 16% soda and 0.5% alumina. If the alumina be increased to the point of maximum effect, which is one-eighth the soda content, the total decrease in chemical attack will be about 33%, which in every case corresponds to a soda decrease of more than 1%. From the viewpoint of an increase in chemical durability or as an increase in resistance to attack, the possible improvement is 50%, instead of 33%.

Acknowledgments

The research reported above was sponsored initially by the Feldspar Association and was concluded under the sponsorship of the Consolidated Feldspar Corporation, Golding-Keene Company, North State Feldspar Corporation, and Seaboard Feldspar Company, to whom acknowledgment is due. Acknowledgment is also owed to J. A. Martz, under whose supervision many of the earlier experimental meltings were carried out.

BAILEY AND SHARP CO., INC.
HAMBURG, NEW YORK

X-RAY STUDIES OF CRYSTALLINE SUBSTANCES IN GLASSES*

By Victor Hicks

Abstract

X-ray diffraction methods may be used not only to determine the atomic arrangements in the vitreous state, but also to detect the substances responsible for color, opalescence, or opacity, and to establish the existence of selective molecular orientation in surface films. By such methods it has been shown that a solid solution of cadmium sulfide and cadmium selenide is responsible for the color of certain ruby glasses. Similarly, the opacity of certain annealed soda-lime-silica-fluoride opal glasses has been attributed either to quartz or to cristobalite, depending on the thermal history; if alumina is added to these glasses, tridymite appears after a similar heat treatment. Chromic oxide has been found to crystallize from certain enamel glasses but not cobalto-cobaltic oxide. No detectable selective molecular orientation occurs in the surface layers of the resinous films used in certain safety glasses.

I. Introduction

Problems concerning the nature of a glass may be approached from the X-ray standpoint in two different ways. The nonequilibrium arrangement of the atoms in the vitreous state may be studied, as B. E. Warren and others have done. By analyses of the angular distribution of the intensity of X-rays scattered from glasses, Warren and his co-workers[1] have shown that, instead of each atom being definitely situated in relation to all others as in a crystal, regularity of arrangement extends over only rather small groups of atoms. Neighboring or nearly neighboring atoms are separated at definite distances, but the orientation of one group with respect to the other groups is not restricted. While these studies have considerably extended the knowledge of the vitreous state, information is not readily obtainable in this manner concerning the compounds which may exist in the uncrystallized solvent or solute in certain types of glasses, for the irregularity of the atomic arrangement usually prohibits structural identifications.

On the other hand, the glass may be brought into partial equilibrium by suitable thermal treatments. The substances responsible for color or for local inhomogeneities, as in opalescent glasses, may be grown into particles containing sufficiently extensive regularity of atomic arrangements to allow their identification by their crystal structures through their diffraction patterns. If the glass is brought to complete equilibrium, information concerning the end products of the chemical reactions produced in making the glass may be obtained. Consequently, the interest in this method of approach lies chiefly in its applications to colored, opal, opalescent, diffusing, or devitrified glasses.

Similar X-ray diffraction methods will yield information of another type, *e.g.*, that concerning selective molecular orientation of substances adhering to glass surfaces. This implies crystallinity of the adhering material.

A number of examples of the successful employment of this method are given here. The application of the results to the field of glass technology, however, are outside the scope of this presentation.

II. Experimental Methods

The diffraction of monochromatic X-rays from the glasses were recorded in these experiments by the usual Debye-Scherrer method.[2] Portions of the annealed glasses, ground to a fine powder, were mixed with a small amount of collodion; the mixture was then packed into a glass tube with an internal diameter of 0.7 millimeter, compressed with a plunger, and finally extruded as a compact cylinder of the same diameter. The glass tube was then mounted in a cylindrical X-ray camera

* Contribution from the Coöperative X-Ray Laboratory, sponsored jointly by the Departments of Physics and of Chemistry and Mellon Institute of Industrial Research at the University of Pittsburgh.

Received February 24, 1936.

[1] (*a*) B. E. Warren, "X-Ray Determination of the Structure of Glass," *Jour. Amer. Ceram. Soc.*, **17** [8] 249–54 (1934), "Diffraction of X-Rays in Glass," *Phys. Rev.*, **45** [10] 657–61 (1934).

(*b*) B. E. Warren and C. F. Hill, "Structure of Vitreous BeF_2," *Z. Krist.*, **89**, 481 (1934).

(*c*) B. E. Warren and A. D. Loring, "X-Ray Diffraction Study of the Structure of Soda-Silica Glass," *Jour. Amer. Ceram. Soc.*, **18** [9] 269–76 (1935).

[2] For a description of this method see, for instance, B. E. Warren, "Identification of Crystalline Substances by Means of X-Rays," *Jour. Amer. Ceram. Soc.*, **17** [4] 73–77 (1934).

of 57.3 millimeters effective diameter in such a way that only the extruded part of the specimen appeared in the X-ray beam. The use of standard-size specimens makes it possible to obtain the interplanar spacings directly from the measurements on the films by means of a conversion table and leads to data which are strictly comparable within themselves, regardless of errors in the apparatus or in the measurements of the dimensions of the cameras. The specimens were rotated or oscillated during the exposure.

Filtered radiation from a copper target, supplied by a demountable, hot cathode X-ray tube, was found satisfactory for these experiments. While clearer photograms could probably have been obtained by the use of radiation made monochromatic by reflection from a crystal and by the evacuation of the cameras, the identifications required were usually easily made when the samples were properly heat-treated.

The interplanar spacings obtained from the photograms have been plotted on partially transparent semilogarithmic coördinate paper. Identifications of pure substances can be made readily by viewing the chart of the data obtained superimposed on reference charts for the substances sought or on simple general reference charts, if the crystal lattice has sufficiently high symmetry.

III. Selenium Ruby Glass

Commercial glasses of various shades and tints of red may be produced by the addition of selenium and cadmium sulfide to a suitable foundation glass. The mechanism of the production of the color, consequently, is of considerable importance. Bigelow and Silverman[3] have obtained a good ruby glass, starting with a foundation glass of the composition $Na_2O{\cdot}ZnO{\cdot}4SiO_2$, by adding the following substances to the basic batch: 2.0% selenium, 1.0% cadmium sulfide, 1.0% arsenic trioxide, and 0.5% carbon. It was suspected that the coloring agent in this glass might be a solid solution of the selenium in the cadmium sulfide.

A sample of this glass was reheated at 350 to 400°C for thirty hours and cooled in the annealing oven. The suspected solid solution was separately synthesized by fusing equimolar amounts of cadmium sulfide and cadmium selenide and subjecting this to the same melting, flashing, and reheating treatment as given the glass. These materials yielded X-ray photograms[4] with relatively sharp lines. The interplanar spacings obtained from the photograms of the glass and the solid solution are given in Table I and are shown graphically in Fig. 1, together with similar data obtained for α-cadmium sulfide and cadmium selenide.

TABLE I

OBSERVED INTERPLANAR SPACINGS (IN ÅNGSTROMS) FOR RUBY GLASS, SOLID SOLUTION, CADMIUM SULFIDE, AND CADMIUM SELENIDE

hkl	Ruby glass	Solid solution	α-cadmium sulfide	Cadmium selenide
100	3.62	3.62	3.55	3.71
002	3.35	3.42	3.34	3.44
101	3.22	3.18	3.13	3.26
102	2.56	2.47	2.45	2.53
110	2.10	2.10	2.07	2.14
103	1.92	1.94	1.90	1.96
200	*			
112	1.79	1.79	1.80	1.83
201	*		1.73	
202	1.59	1.61	1.58	1.64
203	1.415	1.415	1.404	1.451
210	1.378	1.375	1.350	1.400
211	1.344	1.344	1.324	1.368
105, 212	1.271	1.260	1.257	1.302
300	1.209	1.203	1.196	1.235
213	1.172	1.172	1.160	1.198
302	1.140	1.140	1.121	1.165
205	1.095	1.091	1.076	1.115
220	1.040	1.048	1.028	1.070
222, 116	1.000	1.000	.984	1.020
215	.966	.966	.950	1.005
313	.922	.923	.906	.942

* The diffractions from the (200), (112), and (201) planes were not well resolved.

Cadmium selenide and α-cadmium sulfide are known to have hexagonal crystal lattices.[5] The similarity between the diffraction patterns of these substances and the solid solution indicates that the latter has also the same type of structure. The lattice parameters obtained from these diffraction data are given in Table II. The assump-

TABLE II

LATTICE PARAMETERS FOR RUBY GLASS, SOLID SOLUTION, CADMIUM SULFIDE, AND CADMIUM SELENIDE

	a_0	c_0	c_0/a_0
Ruby glass	4.19Å	6.78Å	1.62
Solid solution	4.19	6.85	1.63
α-cadmium sulfide	4.13	6.75	1.63
Cadmium selenide	4.29	6.96	1.63

tion that the fusion of the mixture of cadmium

[3] M. H. Bigelow and A. Silverman, "Selenium Ruby Glass: Preparation and X-Ray Study," *Jour. Amer. Ceram. Soc.*, **16** [5] 214–19 (1933).

[4] The photograms and the diffraction angles used in this investigation were obtained by M. H. Bigelow[3] under the writer's supervision.

[5] R. W. G. Wyckoff, The Structure of Crystals, 2d. ed., p. 225, 1931. The Chemical Catalog Co., New York.

sulfide and cadmium selenide resulted in a solid solution after the heat treatment is confirmed by the fact that the values of its lattice parameters lie between those of cadmium sulfide and cadmium selenide.

The agreement between the diffraction patterns of the solid solution and the glass indicates that the crystalline material in the reheated glass also has a hexagonal structure, the lattice parameters

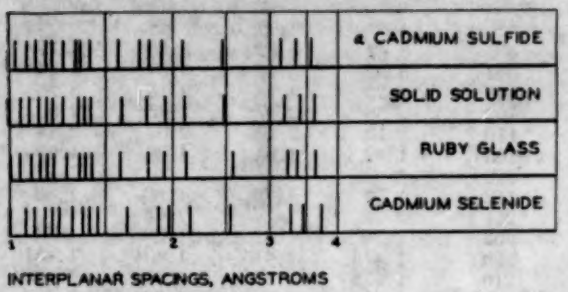

FIG. 1.—Diffraction data for ruby glass.

of which differ from those of the solid solution by 1% or less. It is to be concluded, therefore, that the reheated glass contains a similar solid solution of cadmium sulfide and cadmium selenide with possibly minor amounts of other materials from the glass in addition. In all probability, then, this solid solution is the coloring agent in the glass. No definite X-ray evidence was found for the presence of free quartz, although this might have been obtained if another reheating temperature were chosen, as the following experiments will show.

IV. Opal Glasses

A number of substances have been recognized for some time as capable of producing opacity in enamels and glasses. Regarding the use of sodium fluoride and calcium fluoride as opacifiers in enamels, Andrews, Clark, and Alexander[6] and Andrews and Breen[7] have concluded that crystals of these fluorides are the primary cause of opacity and that the opacity can be attributed either wholly or in part to their presence. By means of X-ray studies, Büssem[8] and Büssem and Weyl[9] succeeded in revealing the presence of sodium fluoride and cristobalite in certain fluoride glasses containing 72 to 78% SiO_2 and 18 to 12% Na_2O, after these glasses had been annealed. Ryde and Yates[10] have found, by similar studies, sodium fluoride and calcium fluoride in certain complex opal glasses, as has Dunbar.[11] In contradiction, however, there seems to be considerable chemical evidence that fluorine may be lost during the melting.[12]

(1) Opal Glasses of Simple Composition

In the X-ray study reported here, the cause of opalescence has been sought in four glasses of simple composition made under carefully controlled conditions.[13] All of these glasses, synthesized from silica, calcium carbonate, calcium fluoride, and sodium fluoride, had the same oxide contents before melting, which were, in parts by weight, SiO_2 100, Na_2O 20.5, and CaO 14.1. The amounts of fluorine were successively increased from 9.6 to 16.3 parts by weight with the simultaneous adjustment of the sodium carbonate. The fusions were made in small platinum pans. Some of these glasses were opalescent after melting; the others became diffusing upon reheating for six minutes between 820° and 870°C.

The diffraction patterns of the glasses which were subjected to no other heat treatment than melting contained only one weak and diffuse band on a rather strong background, which is indicative of the absence of crystalline material.

Samples of these glasses were then given three different reheating treatments. After reheating at 820°C for one hour, diffraction lines were ob-

[6] A. I. Andrews, G. L. Clark, and H. W. Alexander, "Progress Report on Determination of Crystalline Compounds Causing Opacity in Enamels by X-Ray Methods," *Jour. Amer. Ceram. Soc.*, 14 [9] 634–39 (1931); "Determination by X-Ray Methods of Crystalline Compounds Causing Opacity in Enamels," *ibid.*, 16 [8] 385–92 (1933).

[7] A. I. Andrews and J. P. Breen, "X-Ray Investigation of the Opacifying Compounds Present in Sheet-Iron Cover Enamels," *ibid.*, 16 [7] 325–27 (1933).

[8] W. Büssem, "Optical and X-Ray Investigations on Opaque Fluoride Glasses," *Sprechsaal*, 64 [53] 993–94 (1931); *Ceram. Abs.*, 11 [4] 232 (1932).

[9] W. Büssem and W. Weyl, "Fluoride Opacification," *Sprechsaal*, 65 [13] 240–41 (1932); *Ceram. Abs.*, 11 [7] 406 (1932).

[10] J. W. Ryde and D. E. Yates, "Opal Glasses," *Jour. Soc. Glass Tech.*, 10, 274–94 (1926); *Ceram. Abs.*, 6 [3] 97 (1927).

[11] C. Dunbar, "Particle Size and Concentration in Opal Diffusing Glasses," *Jour. Soc. Glass Tech.*, 17, 411–32 (1933); *Ceram. Abs.*, 13 [5] 113 (1934).

[12] H. H. Blau and A. Silverman, "Liberation of Fluorine in Fluoride-Glass Manufacture," *Ind. Eng. Chem.*, 26 [10] 1060–62 (1934); *Ceram. Abs.*, 14 [10] 244 (1935).

[13] These glasses were prepared by H. H. Blau; see H. H. Blau, A. Silverman, and V. Hicks, "Opal Glass: I, Silicon, Calcium, Sodium, Oxygen, Fluorine Series," *Trans. IX Congress of Pure and Applied Chemistry*, 3, 507–34 (1934).

tained which were sharp but rather weak compared to the background. It was possible to identify low-temperature cristobalite, as may be seen from Fig. 2. There was some evidence, although rather uncertain, for the presence of crystallized sodium fluoride. There were also indications of the presence of some other unidentified substances.

A better diffraction pattern was obtained when these glasses were reheated, directly after melting, at 650°C for thirty hours. The principal detectable constituent was low-temperature quartz.

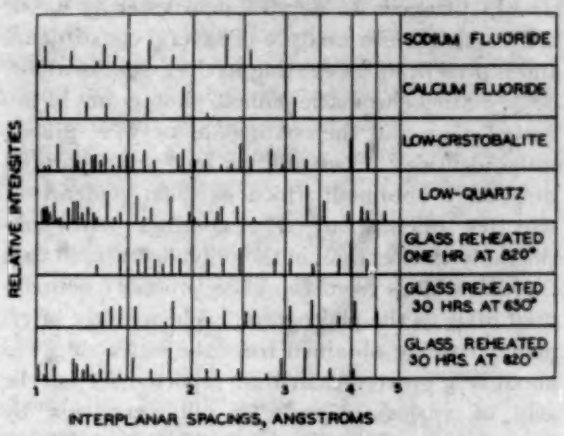

FIG. 2.—Diffraction data for opal glasses of simple compositions.

The presence of cristobalite and of sodium fluoride and calcium fluoride in the crystalline form was possible on this analysis, but rather doubtful.

The diffraction patterns of a fourth set of these glasses, reheated at 820°C for thirty hours, clearly indicated that low quartz had been produced in large amounts. Crystalline sodium fluoride and calcium fluoride were definitely not detectable. Mixtures of these fluorides in the ratios used in the synthesis of the glasses, subjected to this heat treatment, gave the superimposed diffraction patterns of the pure fluorides, showing that no appreciable solid solution or complex compound formation occurred.

Thus, low cristobalite has been obtained with the shorter reheating and low quartz with the longer. The opalescence of these glasses in all probability should be attributed to the presence of these substances. The X-ray studies apparently have not revealed the function of the fluorides in causing opalescence.

(2) Opal Glasses with Added Alumina

An attempt was made to determine the rôle of alumina in producing opalescence by examining a second series of four glasses, which had the previous batch proportions of SiO_2 and Na_2O; alumina was added in 3.4 and 6.8 parts by weight with the coincident adjustment of CaO and fluorine.[14] These glasses were reheated at 820°C for thirty hours and cooled in the air.

A glass, containing no alumina or fluorine and remaining clear after reheating, gave a strong diffraction pattern which was largely identical with that of low quartz.

The remaining glasses in the series also gave strong diffraction patterns; practically all of the

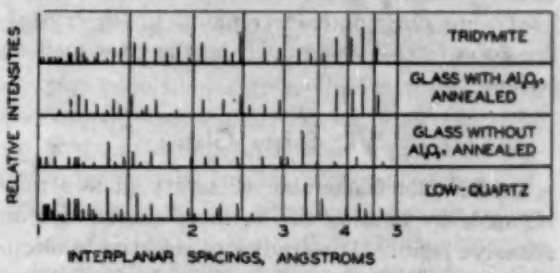

FIG. 3.—Diffraction data for opal glasses with added alumina.

lines of these corresponded to the diffraction pattern of a sample of tridymite,[15] as may be seen from Fig. 3. No definite evidence was found for the presence of any of the modifications of quartz, cristobalite, or alumina, or for sodium fluoride, calcium fluoride, albite, cryolite, sodium fluosilicate, or certain calcium-sodium silicates. It is possible, therefore, that the alumina has acted to promote the growth of tridymite crystals.

The writer has found the complete diffraction pattern of calcium fluoride in a photogram of a sample of a commercial opal glass of as yet unknown composition; in this case, no heat treatment other than that incident to the manufacture was given.

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[14] These glasses were also prepared by H. H. Blau; see H. H. Blau, A. Silverman, and V. Hicks, "Opal Glass: II, Silicon, Calcium, Sodium, Aluminum, Oxygen, and Fluorine Series," *Jour. Amer. Ceram. Soc.*, **19** [3] 63–66 (1936).

[15] M. E. Nahmias has obtained the X-ray diffraction pattern of tridymite from a devitrified glass of the initial composition SiO_2 78, CaO 12, and Na_2O 10; see "X-Ray Investigation of Tridymite Glass," *Nature*, **132** [3344] 857–58 (1933); *Ceram. Abs.*, **13** [3] 56 (1934); and "X-Ray Studies on Bauxite and Mullite," *Z. Krist.*, **85** [5–6] 355–69 (1933); *Ceram. Abs.*, **12** [10–11] 376 (1933).

V. Enamel Glasses

The behavior of chromic oxide and cobalto-cobaltic oxide in simple enamel glasses has been studied. Glasses were made by adding 3 weight per cent of each oxide alone to the batch of an otherwise clear enamel glass; the reheating extended over 30 hours at 400°C.[16] The diffraction pattern of chromic oxide was found for both the heat-treated and not heat-treated glasses to which this compound was added, but no evidence was obtained for crystalline cobalto-cobaltic oxide in the other glass before or after heat-treating, nor was there any evidence for the presence of other crystalline materials in either glass. Accordingly, cobalto-cobaltic oxide is soluble in the enamel glass up to about 3% or more, while at least some chromic oxide remains in the crystalline form or else separates from the glass melt on cooling.

VI. Safety Glass

Certain nonshatterable or safety glasses may be made by binding two or more sheets with an adhesive resin. The studies of selective molecular orientation on various surfaces by Trillat and others[17] leads to the conception that similar orientations might occur on the surfaces of glasses of this type.

One type of safety glass is made by pressing cellulose acetate or vinylite on a surface treated with certain inorganic acids. While the acid coating on these glasses is probably too thin to give rise to detectable X-ray diffractions, it was thought possible that the adherence of the resin might be accompanied by some selective orientation. Debye-Scherrer and so-called "monochromatic pinhole" photograms were made for plates and rods of a soda-lime glass and for these materials coated with resins after acid treatment. Each exposure contained a diffuse ring, the boundaries of which corresponded to interplanar spacings of about 2.60Å and 3.70Å; no rings corresponding to the resins could be detected. Monochromatic pinhole photograms of the resins stripped from the glass, made with the X-ray beam incident on the sheet at various angles, showed only diffuse halos, with no evidence of selective orientation. The outer boundary of these halos corresponded to an interplanar spacing of about 4.0Å, which is the same as that obtained from one of the rings on a photogram of a sheet of plasticized vinylite. Apparently, then, the resin is highly dispersed but not selectively oriented.

In another type of safety glass a highly polymerized, plasticized, acrylic acid ester is used; the plasticizer is a mixture of several constituents and is present in the coating to the extent of about 30%. Monochromatic pinhole photograms of the coated glass and the coatings alone were practically identical. Two diffuse but well-separated rings were obtained, which gave no evidence of selective orientation. The coatings were considerably thicker than in the previous case, so that the diffractions from the glass probably contributed little to the photogram. The average interplanar spacing obtained from the outer ring was about 5% greater than that reported for acrylic acid of various degrees of polymerization by Katz,[18] indicating that some of the plasticizer may have gone into solid solution in the resin.

From these studies, it is apparent that, if selective orientation does occur in the attachment of resinous films of these types to glass surfaces, such orientation does not extend far beyond the surface layers.

Acknowledgments

The writer wishes to express his appreciation to M. H. Bigelow for permission to use his diffraction angles obtained in the study of the selenium ruby glass. The writer is also grateful to the following individuals for permission to publish these results: E. H. Balz, D. G. Bennett, F. L. Bishop, H. H. Blau, and A. Silverman.

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[16] These glasses were made and heat-treated by D. G. Bennett at Mellon Institute of Industrial Research.

[17] J. J. Trillat, Les Applications des Rayons X, p. 198, 1930. The Press of Univ. of France, Paris.

[18] J. R. Katz, "Influence of Polymerization on the X-Ray Diagram: I, High Polymerization with Amorphous X-Ray Spectra," *Z. physik Chem.*, **125**, [5–6] 321–30 (1927).

A COMPARISON OF RESULTS OF DIFFERENT INSTRUMENTS FOR MEASURING REFLECTANCE*

By G. L. Bryant and F. R. Porter

Abstract

The reflectance of a set of six standard white porcelain enameled panels of various enamel thicknesses was measured by six different types of reflectivity instruments used for the purpose. A brief description of each instrument and also the comparative measurements are given.

I. Introduction

It is the object of this report to sketch briefly the basic principles of some of the instruments for measuring the reflectance values of enamels and to bring out the fact that some closer standardization is required than standardizing each instrument upon the reflectance value of magnesium carbonate or magnesium oxide.

Six panels, 4 by 6 inches, were prepared in ground coat and sprayed with a commercial enamel so that each panel had a thicker coating than the previous panel. The weight range covered was approximately 20 to 65 grams of dry enamel per square foot. The panels were obtained in one firing operation.

The panels were then sent to six companies or laboratories having reflectometers, and the reflectance of each panel was measured.

II. Reflectance Instruments for Tests

Type 1

The equipment consists of a stand with a sample holder, an illuminating sphere, and the Martin polarization photometer (see Fig. 1). The stand of triangular form is equipped with a rack and pinion movement, *R*, for raising and lowering the sample stage, *T*. A special sample holder *H*, can be provided for holding the sample, *S*, and comparison standard, *St*.

The diffuse illumination of the objects under test is obtained by the integrating sphere, *I*, made of a white metal alloy casting in two halves; the inside wall is accurately turned to a sphere and coated with magnesium oxide, which forms a white diffusing reflector. Four electric 6-volt bulbs, *E*, of the shielded filament type are used for the indirect illumination of the test object. Only light reflected from the sphere wall falls on the test object.

Surface reflection measurements are made by measuring the sample under test against the magnesium oxide-covered inner sphere wall of the instrument. A check on the reflection value of the sphere wall should be made from time to time by measurably comparing it with a MgO standard.

The sample is placed on the stage, *T*, and raised against the sphere by the rack and pinion movement, *R*. By looking through the photometer, two semicircular image fields forming the photometric comparison field are observed. The two image fields are brought to a match of uniform brightness by turning the analyzer head, *A*, until the dividing line between the image halves disappears. At this position, the angular degree reading of the analyzer scale is noted, and the matching is repeated three or four times to obtain a good average reading. The percentage reflectance is read from a graph showing the relation between the angular reading in degrees and percentage reflectivity.

Type 2

The essential elements of this instrument are as follows: a housing shaped like a 90° quadrant of a circle, a projector, a voltmeter, a rheostat for controlling the lamp, and the light-sensitive voltaic cells.

In this type of instrument, the reflectance is measured by directing a beam of light on the test sample and then measuring the light reflected from the sample through an angle of 90°, with the projected beam as the starting point. This is accomplished by placing the light-sensitive cells at definite angles in the right-angle quadrant and equipping them with apertures or screens correcting their current outputs in proportion to the zone areas. By connecting the cells, a reading may be obtained on the voltmeter, graduated to read in percentage reflectance regardless of distribution characteristics, which represents the amount of light reflected from the sample.

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division).

The beam of light is projected through a distance of 24 inches to the test sample and almost entirely covers the part of the sample exposed through the circular window. The cells are mounted on the inside of the quadrant on a 22-inch radius. The cell housing is made light-tight

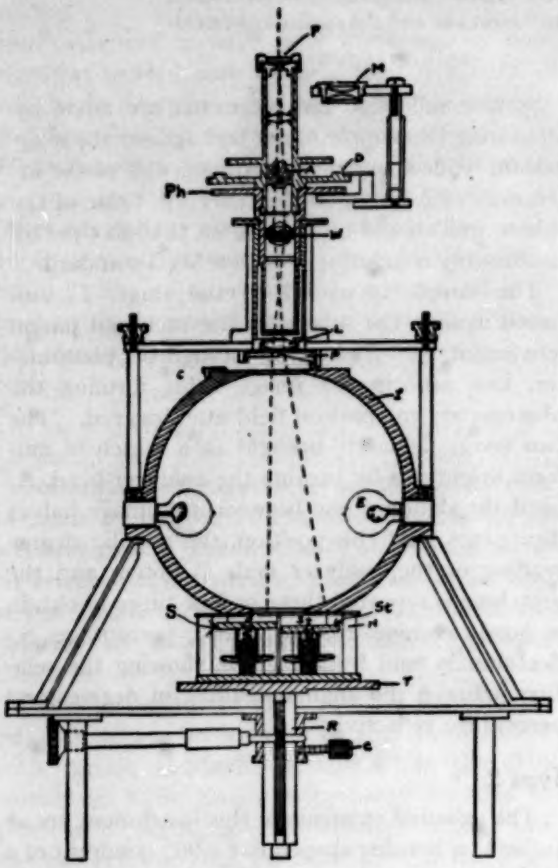

FIG. 1.

by a cover removable from the back, so the apparatus is not limited to a dark room. All surfaces inside the housing are painted a flat black to minimize the effect of reflected light from the interior surfaces. A diagram is shown in Fig. 2.

Type 3

This instrument is divided into four parts, consisting of a silvered sphere containing a light source to give a diffused illumination, a photronic cell, an ammeter to register the intensity of light, and a voltage regulator (see Fig. 3).

The diffused light falls upon the enameled plate and is reflected through two lenses, focusing the reflected light upon the sensitive part of the cell. The photronic cell generates a current which varies according to the amount of light focused on it. The change in current value is indicated by an ammeter graduated from 0 to 100% in 2% increments in the photronic-cell circuit.

In operation, the instrument is turned on and allowed to warm up. When the indicator has become constant, the instrument is balanced by placing a magnesium-carbonate block in the machine and setting the indicator at 100% by means of a coarse and fine rheostat in the light circuit. The magnesium carbonate block is then removed and the enamel plate substituted. The pointer will then gradually swing to the percentage reflectivity as recorded by the instrument. The swing is not abrupt as the instrument is damped to obtain a reading of five seconds.

Type 4

For purposes of description, this instrument may be broken down into two sections, which may be called the illumination and the receptor systems. The first provides a strong constant illumination which is projected upon the sample to be measured. The second detects and measures the amount of light reflected from the sample under a rigidly established set of conditions.

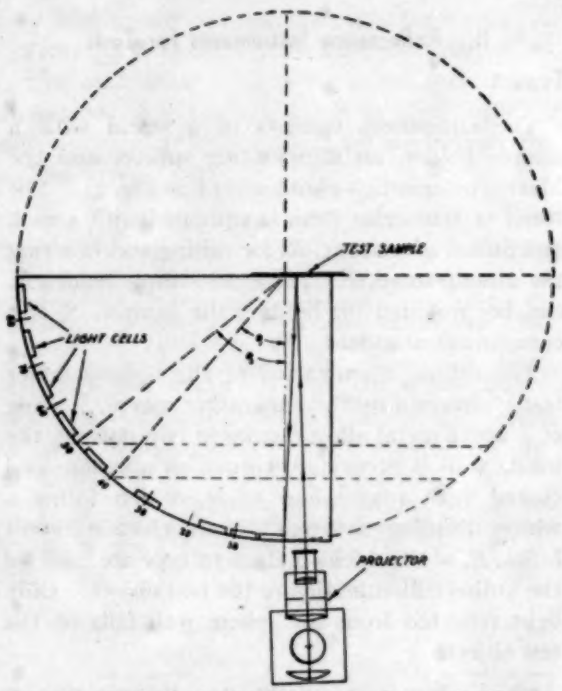

FIG. 2.—Principle of operation of quadrant distribution reflectometer.

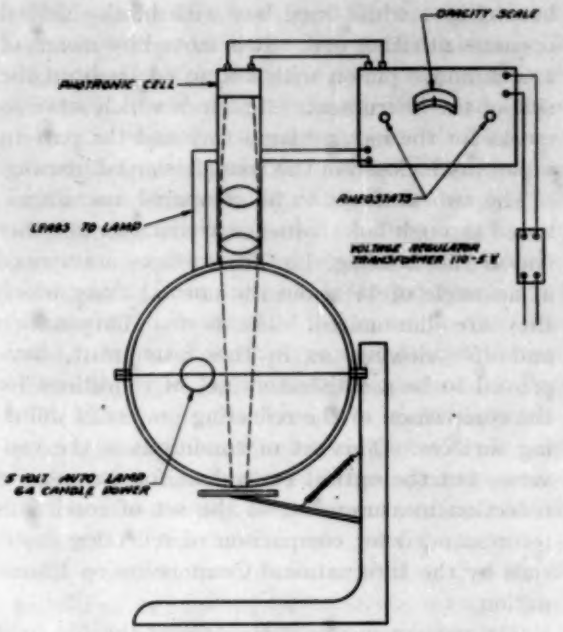

FIG. 3.

The illuminant is a 32-candle power, 6-volt auto headlight bulb (1, Fig. 4), operated from the alternating-current mains through a special Westinghouse transformer of the voltage regulator type. This regulator smooths out both slow and sudden changes in line voltage and maintains on the low voltage output side a constant voltage over all ordinary variations in the alternating-current supply. The regulator is designed to deliver about 6.4 volts, thus slightly overvolting the lamp and giving a more intense, whiter light. This source is imaged approximately in a small circular diaphragm which is in turn imaged upon the sample aperture. A variable diaphragm in the projection system controls the amount of light falling upon the sample.

The receptor system consists of an integrating cube, 4, in the wall of which is the sample aperture, 11 (see Fig. 4). The integrating cube is essentially an inclosed unobstructed space of the shape designated, into which a source of illumination is introduced. The inner walls of the inclosed space are painted with some white diffusing material of high reflecting power which serves to reflect the light back and forth many times within the cube, thus creating a condition in which the entire inside area is evenly illuminated. The projection system, in this case, throws a beam of light through one aperture on the integrating cube and images a diaphragm upon the sample aperture in the opposite face. On a third face is mounted a Weston photronic cell, 9, with its sensitive surface facing the interior. With no sample in position over the aperture, the beam passes completely through the cube. When the sample is placed in position, light is reflected from it back

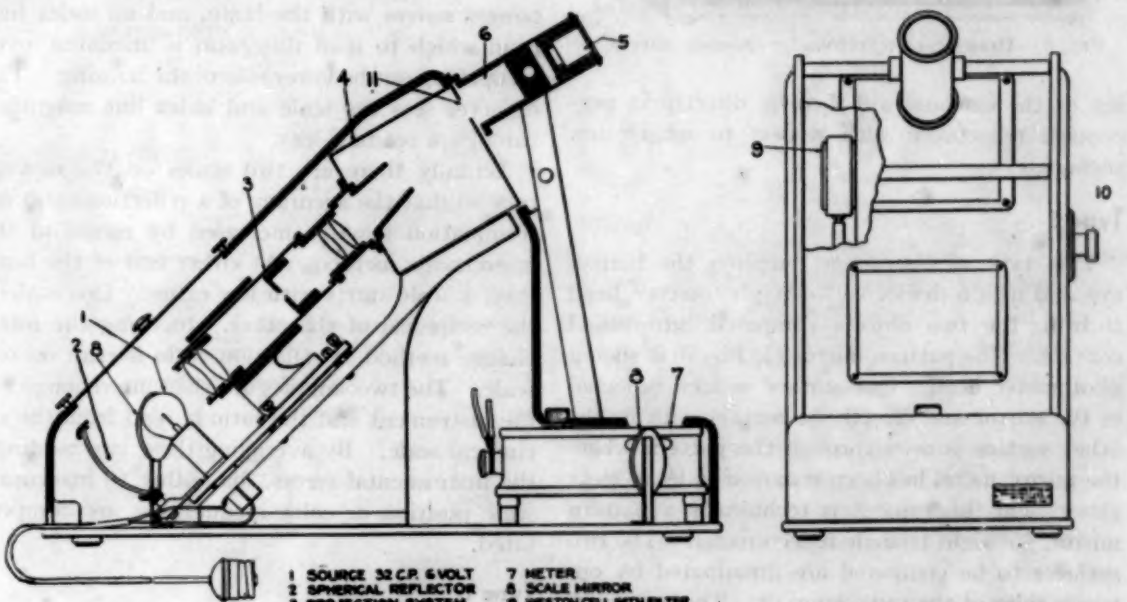

FIG. 4.

into the cube and thus caused to fall on the active surface of the cell. The current generated by the action of the integrated light is read upon a Weston microammeter, 7, having a scale range of approximately 15 microamperes.

The operation of the instrument is as follows: A freshly scraped block of magnesium carbonate is placed over the sample aperture and the ammeter is adjusted to read 10.0. The block is removed, and the sample substituted. The reading of the machine will then be directly in percentage reflectance with respect to magnesium carbonate.

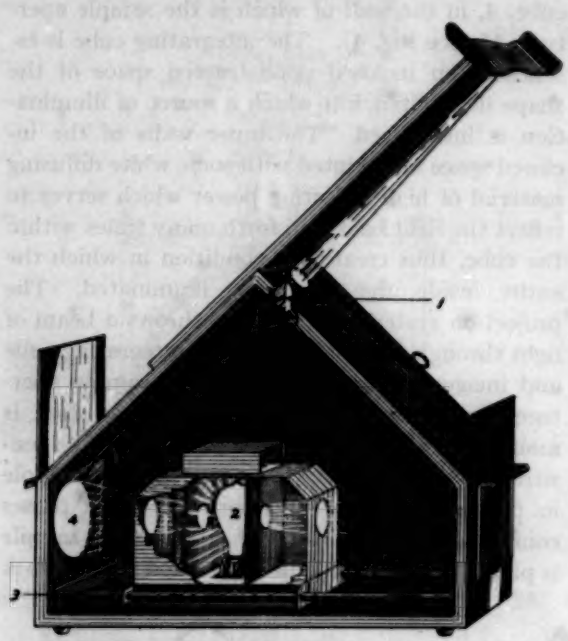

FIG. 5.—Drawing of reflectometer showing interior.

Type 5

This type of instrument employs the human eye and uses a device called a photometer head to bring the two objects compared into visual contact. The pattern mirror (1, Fig. 5) is such a photometer head. One surface is seen reflected in the mirror and directly in contact with it; the other surface is seen through the pattern where the mirror metal has been removed to leave clear glass. This instrument is technically a pattern mirror, 45° right triangle reflectometer. The two surfaces to be compared are illuminated by opposite sides of the same lamp, 2. The motion of this lamp between these surfaces provides variable illuminations upon them. The lamp itself is housed in a white-lined box with black-shielded openings at either end. It is moved by means of a rack and a pinion with a knurled knob on the side of the instrument. The rods which serve as tracks for the moving lamp tray and the pattern minor are inclosed in the triangle-shaped housing.

The two surfaces to be compared are illuminated through holes 3 inches in diameter at either end of this housing, 4. The surfaces are viewed at an angle of 45° from the normal along which they are illuminated. The normal illumination and 45° viewing, as in this instrument, have proved to be a satisfactory set of conditions for the comparison of the reflecting powers of diffusing surfaces. This set of conditions is the converse, but the optical equivalent for purposes of reflection measurement, of the set of conditions recommended for comparison of reflecting materials by the International Commission on Illumination.

The pattern mirror at the apex of the 45° right triangle is mounted just inside the top of the instrument housing.

The nonuniformities in most reflecting surfaces are large enough to cause the pattern of the mirror to disappear unevenly around the position of balance. It is to provide a reference object within the field that the narrow horizontal line is scratched on the mirror.

A scale to indicate the ratio of light-reflecting powers moves with the lamp, and an index line from which to read this ratio is mounted over an opening on the lower side of the housing. The observer sees the scale and index line magnified through a reading lens.

Actually there are two scales on the moving tray so that the accuracy of a reflection-ratio determination may be increased by means of the interchange method. At either end of the lamp tray, a scale starts with low ratios. One scale is the reciprocal of the other. In using the interchange method, a reflection ratio is read on one scale. The two samples are then interchanged in the instrument and the ratio is read from the reciprocal scale. By averaging these two readings, the instrumental errors, due either to inaccurate scale position or color inequalities, are compensated.

Type 6

This type of instrument is a photoelectric device which automatically plots a spectrophoto-

metric curve of a sample in the visible spectrum, *i.e.*, between 400 and 700 millimicrons. The operation of this device is essentially as follows: Light from a vertical ribbon-filament lamp passes into the slit of a dispersion system. Emerging from this system through another slit as monochromatic light, *i.e.*, 10 millimicrons band, it uniformly fills a collimator lens. Here it is divided: one-half is taken off with a right-angle prism and brought to focus on the sample and one-half goes through the shutter and is focused on the flicker disk, which is coated with a neutral white lacquer. Light reflected from the sample is collected and brought to a focus in the plane of the flicker disk and is then transmitted to a photoelectric tube. As the disk revolves, the photoelectric tube views alternately the disk and sample at a rate of 60 alternations per second. A greater amount of light reflected from either sample or flicker disk results in a pulsating photoelectric current which is amplified electrically and used to control a motor-operated shutter in the light path incident on the flicker disk. This shutter will operate until the beams are of equal intensities. A pen attached to this shutter records on the chart the degree of shutter opening. As the recording drum revolves, the wave-length of light passing through the exit slit of the monochrometer is varied at a uniform rate from 400 to 700 millimicrons. The curve thus obtained indicates at each wave-length the position of the shutter which allows an amount of light to be reflected from the flicker disk equal to that being reflected from the specimen. The shutter is so constructed that the opening is directly proportional to the amount of light transmitted and thus the ordinates of the curve become proportional to reflection of the specimen. It is routine practice to make a curve on magnesium carbonate and then one on the sample. The ratio of the sample ordinates to those for magnesium carbonate is the reflecting power in terms of magnesium carbonate.

The power source for the analyzer consists of 100-volt 60-cycle alternating current to supply the power transformer, flicker motor, and 8-volt direct current for lamp-filament currents.

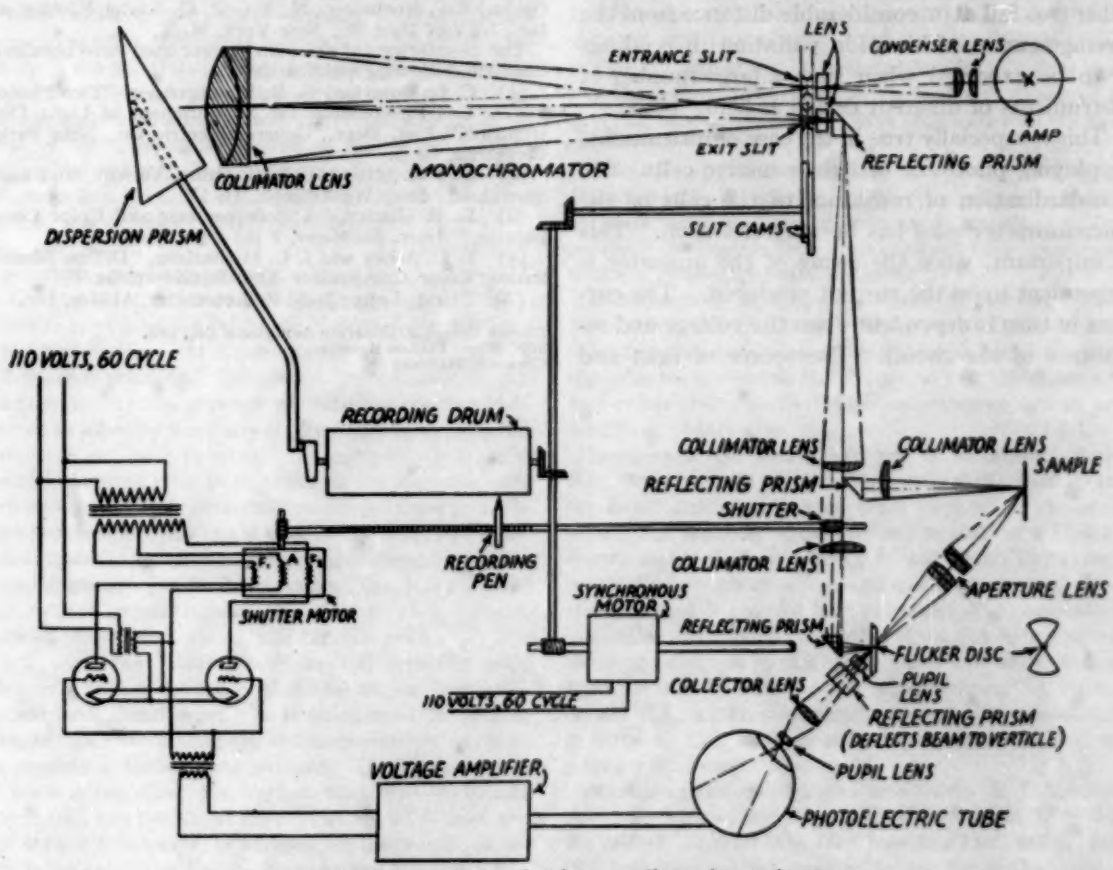

FIG. 6.—Schematic drawing for recording color analyzer.

Approximately $3^1/_2$ minutes are required to obtain a curve. Transmission samples are measured by introducing them in the beam incident on the specimen. Magnesium carbonate is usually used in the specimen holder in such measurements. It is generally recognized that such a spectrophotometric curve constitutes the most fundamental specification of color.

III. Results of Tests

The results of the reflectance measurements of each instrument are shown in Table I.

TABLE I

Panel No.	Grams/ft.²	Instrument types (% reflectance)					
		No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
418	20.8	53.0	54.0	47.3	54.0	51.9	54.3
420	30.0	61.5	62.0	55.4	63.0	59.7	62.2
421	34.8	66.2	66.0	61.3	68.5	65.7	66.9
422	41.5	69.7	70.0	65.4	71.5	69.9	70.5
423	51.8	74.0	74.0	70.8	76.0	74.2	75.0
424	63.1	76.6	77.5	75.0	80.0	78.3	77.8

Four of the instruments have weight reflectance curves which lie within 2% of each other. The other two fall at a considerable distance from the average curve. This wide variation in readings is to be expected when such a large number of instruments of different design is being used.

This is especially true in the case of instruments employing photronic or light-sensitive cells. No standardization of resistance of the cells or the microammeter used has been agreed upon. This is important, since the swing of the ammeter is dependent upon the current produced. The current in turn is dependent upon the voltage and resistance of the circuit. The source of light and inner coating of the housing is different in each instrument. With so many designs, it is rather difficult to expect close coördination in the readings of the instruments.

This problem might be solved by setting up some instrument as a standard. Panels of different weight applications from 20 to 70 grams per square foot could be made and the reflectance measured. One set should be retained in the National Bureau of Standards to check the standard instrument. The other panels could be made available to companies desiring them. With a standard set of panels with each instrument, it will be possible by means of a curve to correct the reading of the instrument to a national standard.

Acknowledgment

The writers wish to express their sincere appreciation to the following men and companies for their aid and coöperation in obtaining these data: J. L. Michaelson, General Electric Co., Schenectady, N. Y.; Richard S. Hunter, Henry A. Gardner Laboratory, Washington, D. C.; Dr. Schoenberg, Light Research Corp., Niles Center, Ill.; G. H. McIntyre, Ferro Enamel Corp., Cleveland, Ohio; B. T. Sweely, Chicago Vitreous Enamel Product Co., Cicero, Ill.; C. J. Kinzie, Titanium Alloy Mfg. Co., Niagara Falls, N. Y.; W. H. Slocum, Bausch & Lomb Optical Co., Rochester, N. Y.; C. C. Rudolph, Akatos, Inc., 55 Van Dam St., New York, N. Y.

The descriptions of the instruments used were obtained from the following publications:

(1) C. L. Dows and G. R. Baumgartner, "Two Photovoltaic Cell Photometers for Measurement of Light Distribution," Eng. Dept., General Electric Co., Nela Park, Cleveland, Ohio.

(2) *Circular*, No. 461, Natl. Paint, Varnish, and Lacquer Assn., Inc., Washington, D. C.

(3) R. S. Hunter, "A Reflectometer and Color Comparator," *Amer. Enameler*, 7 [6] 4–6 (1934).

(4) L. C. Athey and J. L. Michaelson, "Diffuse Illumination Color Comparator and Reflectometer."

(5) Priest, Lange Judd Reflectometer, Akatos, Inc.

EDISON GENERAL ELECTRIC APPLIANCE CO., INC.
5600 WEST TAYLOR STREET
CHICAGO, ILLINOIS

CERAMIC ABSTRACTS

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The bold-face number following the journal name is the volume; the issue number is in brackets, followed by the page numbers, then the year in parentheses.

Vol. 15 **May, 1936** **No. 5**

Abrasives

Abrasive cleaning without compressed air. Anon. *Iron & Steel Ind.*, **8** [6] 232 (1935).—Though patents appeared as early as 1870, difficulties persisted until overcome recently in the apparatus of the American Foundry Equipment Co. The chief difficulties were protection of the apparatus itself from abrasion and directional control of the abrasive. The apparatus, known as the "wheelabrator," originally developed, "successfully replaces acid pickling, wire brushing, abrasive scrubbing, and other methods of cleaning sheets, shapes, billets, and forgings." E.H.McC.

American grinding technics. H. Krug. *Schleif & Poliertech.*, **12** [12] 231–43 (1935).—American technics as shown in the Cleveland exhibition, held in Sept., 1935, are of the highest class. 44 illustrations. F.E.V.

Centerless grinding. Editorial. *Indian Eng.*, **90** [21] 446 (1931).—(1) The principle of centerless grinding is explained as allowing work to pass freely along the grinding surface of an abrasive wheel. In an ordinary grinding machine the work must be mounted on the operating table between centers. A centerless grinding machine is designed to eliminate this loss of time by allowing the work to pass automatically between two abrasive wheels on a work-supporting rest. (2) Its limitations are that it is primarily a production process applicable mainly to plain cylindrical work, shouldered pieces, and tapered work. (3) The B.S.A. centerless grinding machine will regularly grind work to within a tolerance of 0.0002 in. on reasonably straight and round work. It is guaranteed to produce more accurate work than the ordinary grinding machine. Its important features are outlined. (4) The machines are made in two sizes; No. 5 grinds work from $^1/_{16}$ to 3 in. in diameter, and the No. 12 from $^1/_4$ to $5^1/_2$ in. in diameter. The capacity, however, is affected by the weight of the part to be ground as well as its diameter. A.P.S.

Cutting oils and their fundamental characteristics. W. D. Huffman, C. B. Harding, and W. H. Oldacre. *Iron Age*, **134** [19] 36–38 (1934).—The general types of cutting oils are (1) soluble and (2) nonemulsifiable. There is a recent trend toward increased use of emulsions. Compounds of sulfur, fats, and mineral oil have been used with fair success. E.H.McC.

Efficiency of grinding wheels. P. Postel. *Schleif & Poliertech.*, **12** [12] 244–46 (1935).—The influence of bond, hardness, and particularly velocity is described. The necessity of duration tests is emphasized. For important works, a technologist may be useful. F.E.V.

Electrocoating sandpaper. Durex Abrasives. *Elec. Rev.*, **118** [3035] 121 (1936).—The plant and process used in placing abrasive grains on paper or cloth backings under the influence of electrostatic charges so that the grains adhere evenly spaced and with sharpest points uppermost are described. Illustrated. J.L.G.

Inexpensive rock-slicing machine. B. M. Shaub. *Econ. Geol.*, **30** [8] 916–22 (1935).—The cutter is the usual rotating metal disk of soft steel, brass, copper, or phosphor bronze. S. mounted it directly on the shaft of a $^1/_4$-h.p. electric motor of about 1725 r.p.m. and used a Delta compound feed to advance the section during cutting. The abrasive used is crushed bort (diamond dust) suspended in vaseline and applied to the edge of the disk by a grooved charging roller. A special splash guard and water-cooling device is used to cool the disk and specimen. A quartz crystal of 2.2 sq. in. cross-section was cut with a steel disk in 36 sec. Cut surfaces need but a small amount of grinding afterward. Illustrated. J.L.G.

Measuring and specifying surface finish. E. J. Abbott. *Jour. Soc. Automotive Engrs.; Metal Treatment*, **1**, 92–94, 101 (1935); abstracted in *Jour. Iron Steel Inst.*, **132** [2] 445 (1935).—Some results obtained by the use of the Profilo-

graph (an instrument which traces over the surface with a diamond point, the movements of which are magnified and optically recorded) are discussed. The irregularities so revealed, when drawn to true scale, are gently undulating; but by compressing the horizontal scale the surface roughness may be made to appear much more pronounced. Several such curves, termed profilograms, are reproduced. It is further shown that two kinds of irregularity may be distinguished: roughness and waviness. A. suggests a method of rating surfaces according to the magnitude of the peaks and valleys exhibited by the profilogram and examines alternative methods of determining and assessing surface finish. He considers that, of these methods, visual comparison with standard specimens and the use of the electrical pick-up (gramophone needle) are the most promising; however, they should be based on, and correlated with, the profilograms.

Polishing wheel adhesives and abrasives. Fred B. Jacobs. *Metal Cleaning & Finishing*, **8** [2] 73–75 (1936).—The strongest adhesive known is Russian isinglass, a preparation of nearly pure gelatin made from the viscera of fish, but its cost is too high for common use. Strong elastic wheels are made by hot-pressing mixtures of ground shellac and abrasive. Ordinary fish glue, silicate of soda, and a special mineral compound which acts as a cement are used in setting up polishing wheels. E.J.V.

Practical hints for users of grinding wheels: III. Anon. *Schleif & Poliertech.*, **12** [10] 197–99 (1935).—The shape of abrading wheels is as important as grading or hardness. Conical wheels are not to be avoided in certain cases although surface of attack and heat evolved are unusually great. Substitution of segments for hollow conical wheels is advisable for automatic or semiautomatic grinding but is dangerous for hand work. If the dimensions of the wheel are increased, it is necessary either to increase the dimensions of the grains or to reduce their hardness. Conical shapes require bigger and softer grains than cylindrical wheels. The efficiency of dry grinding is about 30% superior to wet grinding. If thermal conditions permit, the dry process is always used. For wet grinding, water must be supplied rather in excess. Different ways of employing wheels are briefly discussed. See also *Ceram. Abs.*, **15** [3] 80 (1936). F.E.V.

Safety devices for grinding and polishing machines. Brauer. *Oberflächentech.*, **13** [2] 17–18 (1936).—Special devices are shown by which injuries to workmen on polishing and grinding machines with projecting shafts with interior thread are eliminated; the fingers of the operator were often caught in the thread. M.H.

PATENTS

Abrading machine. A. S. Johnson (United Shoe Machinery Corp.). U. S. 2,032,418, March 3, 1936 (Dec. 11, 1931).

Abrasive article. F. J. Tone (Carborundum Co.). U. S. 2,033,263, March 10, 1936 (April 18, 1932). The method of compensating for distortion or nonsymmetry in an abrasive wheel comprises applying to each of the opposite faces of the wheel a layer of substantial thickness of nonmetallic material which is plastic throughout the layer at some time during the process of application but hardenable, confining the layers around their edges while permitting outward flow of a portion of the plastic material, simultaneously compressing the layers against the sides of the wheel to a predetermined thickness by applying pressure to them from members which are parallel to one another, meanwhile supporting the wheel solely by contact with the layers, and while the layers are thus compressed curing the material of which they are composed to permanently set them in the shape thus occupied.

Abrasive cutting machine and method. Dartrey Lewis, W. L. Walsh, and W. B. Lashar, Jr. (American Chain Co., Inc.). U. S. 2,031,052, Feb. 18, 1936 (April 18, 1934).

Abrasive element. W. J. Ellis. U. S. 2,032,356, March 3, 1936 (Feb. 28, 1934).

Abrasive machine. V. R. Pallas. U. S. 2,033,393, March 10, 1936 (Aug. 27, 1934). U. S. 2,033,394, March 10, 1936 (Feb. 12, 1935).

Abrasive machine and process. V. R. Pallas. U. S. 2,033,392, March 10, 1936 (Jan. 22, 1934).

Abrasive saw. Fred Bley (Martin Hoerer). U. S. 2,032,395, March 3, 1936 (Oct. 15, 1934).

Abrasive supporting member and method of producing. K. H. Bowen (Columbian Rope Co.). U. S. 2,032,249, Feb. 25, 1936 (June 10, 1935). An abrasive supporting member comprises a core adapted to be mounted for rotary motion, a fibrous laterally flexible disk-like body extending radially from the core, and a plurality of laterally flexible pins extending radially from the core into the fibrous body.

Abrasive wheel-forming device. Easterbrook, Allcard & Co., Ltd., A. G. Gardner, and J. W. Inger. Brit. 442,156, Feb. 19, 1936 (Aug. 3, 1934).

Abrasive wheels. H. Reynolds. Brit. 441,498, Feb. 5, 1936 (July 21, 1934).

Buffing wheel. E. W. Hall. U. S. 2,031,105, Feb. 18, 1936 (Aug. 3, 1934).

Combination precision grinder and calipers. H. B. Barrett. U. S. 2,031,357, Feb. 18, 1936 (July 10, 1933).

Devices for polishing the rolls of rolling mills. F. Cooper and H. P. Lloyd. Brit. 442,483, Feb. 19, 1936 (July 27, 1935).

Gear-lapping machine. E. A. Overstedt (Michigan Tool Co.). U. S. 2,032,589, March 3, 1936 (Aug. 7, 1933).

Grinding machine. Raphael Atti. U. S. 2,030,850, Feb. 18, 1936 (July 1, 1931; June 10, 1933). Sol Einstein, Clement Booth, and F. S. Haas (Heald Machine Co.), U. S. 2,032,269, Feb. 25, 1936 (June 28, 1929). F. S. Haas and B. A. Kearns (Cincinnati Grinders, Inc.), U. S. 2,033,335, March 10, 1936 (April 4, 1932). H. W. Kulp and M. C. Dellinger (K-D Mfg. Co.), U. S. 2,032,538, March 3, 1936 (June 20, 1933).

Grinding machines and methods of grinding. Heald Machine Co. Brit. 442,941, March 4, 1936 (Aug. 14, 1933).

Grinding machinery. Sol Einstein, Clement Booth, and F. S. Haas (Heald Machine Co.). U. S. 2,032,268, Feb. 25, 1936 (June 26, 1929).

Grinding and polishing device. Albert Knaff. U. S. 2,033,034, March 3, 1936 (Jan. 23, 1933). A device for grinding and polishing flat surfaces, more especially in the manufacture of plate glass.

Grinding-wheel mandrel. J. H. Blair (Chayes Dental Instrument Corp.). U. S. 2,030,910, Feb. 18, 1936 (March 21, 1933).

Grinding wheel and treatment thereof. N. G. Anderson and A. F. T. Lofquist (Norton Co.). U. S. 2,033,668, March 10, 1936 (Nov. 19, 1935). As a new article of manufacture, a vitrified ceramic bonded grinding wheel has in its pores a deposit of a deliquescent chloride.

Honing tool. F. L. Gillett and J. S. Morgan, Jr. (National Superior Co.). U. S. 2,031,156, Feb. 18, 1936 (May 22, 1933).

Lap-forming apparatus. Jules Weinbrenner. U. S. 2,032,076, Feb. 25, 1936 (June 23, 1934).

Machine for grinding or polishing extended surfaces. M. Fairest and L. Padley. Brit. 442,380, Feb. 19, 1936 (Sept. 22, 1934).

Machine for making grinding wheels. J. G. Goodhue (Security Grinding Wheel Co.). U. S. 2,031,158, Feb. 18, 1936 (Dec. 31, 1931).

Manufacture of abrasives. I. G. Farbenindustrie A.-G. Brit. 442,599, Feb. 26, 1936 (Aug. 12, 1933).

Process of grinding. J. E. Caster and L. F. Nenninger (Cincinnati Grinders, Inc.). U. S. 2,033,324, March 10, 1936 (April 17, 1926; Dec. 16, 1930).

Rail-grinding machine. A. S. Kalenborn (Welding Service, Inc.). U. S. 2,032,419, March 3, 1936 (Jan. 13, 1930).

Segmental grinding wheel. W. C. Herman (Carborundum Co.), U. S. 2,032,362, March 3, 1936 (April 23, 1934). G. N. Jeppson (Norton Co.), U. S. 2,032,484, March 3, 1936 (June 13, 1935).

Self-contained grinding wheel head. G. S. Gould. U. S. 2,032,011, Feb. 25, 1936 (May 7, 1935).

Water-resistant sandpaper, etc., and process of making. Carleton Ellis (Ellis-Foster Co.). U. S. 2,031,362, Feb. 18, 1936 (Feb. 18, 1927; Sept. 9, 1933). An abrasive sheet comprises paper rendered water-resistant by wax deposited from emulsion in the paper stock, the water-resistant paper carrying a coating of abrasive grit bound to the surface by a binder comprising a nitrocellulose composition.

Art and Archeology

Ancient technical progress. H. H. Slawson. *Sci. Amer.*, **153** [1] 10–11 (1935).—From excavations at Tell Asmar, near Baghdad, Henri Frankfort, Oriental Institute, University of Chicago, reports the discovery of (1) glass dating from B.C. 2700 to 2600, (2) evidence that terrestrial iron was employed for weapons before B.C. 2700, and (3) four arched doorways, three of which were completely intact. All other excavations of glass of the same quality date from more recent times. W.M.C.

Ceramic craft work in secondary schools. Luke F. Beckerian *et al.* *Bull. Amer. Ceram. Soc.*, **15** [3] 125–26 (1936). **Discussion.** E. de F. Curtis *et al.* *Ibid.*, pp. 126–27.

Ceramic sculptures by Aitken at the Walker Galleries. E. M. Benson. *Amer. Mag. Art*, **29** [2] 109–10 (1936).—Russell Aitken is a craftsman of ingenuity and skill and a born wit. He promises to be one of America's master *kleinkunst* makers. E.B.H.

Ceramic texts and materials to aid schools and craftsmen. H. R. Bacher. *Bull. Amer. Ceram. Soc.*, **15** [3] 127–28 (1936).

Ceramics: two pottery technics. Linn L. Phelan. *Design*, **37** [8] 32–34 (1936).—Two methods of decorating clay are graffito and mishima, the former a method of antiquity and the latter originating in Korea. In graffito, a design is incised through a clay of one color to that of another. When the design is incised in the body of a ware, washed over with a slip which fills the lines, after which the excess slip is cleaned away, it is called "mishima." Illustrated. E.B.H.

Creative expression through ceramic art. Mabel C. Brady. *Bull. Amer. Ceram. Soc.*, **15** [3] 96–98 (1936).—Illustrated.

Exhibition of Chinese Art: No. 2, Bronzes, jades, porcelain enamels. William King. *Connoisseur*, **97** [413] 9–15 (1936).—The art of the potter is represented by (1) one of a pair known as "Fighting Horses," of unglazed ware with traces of blue, red, and black pigment; (2) a vase from the Sung dynasty with three rams' heads in relief, the crackled glaze being a delicate grayish blue; (3) a jug of the Ming dynasty (Hsüan Tê period) with the underglaze known as "sacrificial red"; and (4) a bowl of *famille verte* enamels of the Ch'eng Hûa period. The Ming dynasty saw the development of painting in overglaze enamel colors and in underglaze blue and red. Tradition dates the introduction of enameling into China in the Yüan dynasty, A.D. 1280, but the earliest shown are of the Chïen Lung period of the Ming dynasty. Another type of Chinese enamel represented is known as "Canton enamel." Illustrated. E.B.H.

Glass-painters in England before the Reformation. C. Woodforde. *Jour. Brit. Soc. Master Glass-Painters*, **6**, 62–69 (1935–36); *Jour. Soc. Glass Tech.*, **19** [76] A429 (1935).—Authorities suggest that schools of glass-painting were situated at York, Coventry, one near Northampton, Bristol, Wells, Winchester, Canterbury or Dover, Oxford, Lincoln, Norwich, and Westminster. The influence of York spread far, and it was, in turn, influenced by great centers elsewhere. According to J. A. Knowles, the first York glass-painter known by name was Walter le Verrour, whose name occurs in 1313. There were 13 other names before 1360, 13 before 1400, 27 before 1450, 27 before 1500, and 20 before 1540. In the year 1221, John and Albin le Verur were working in Winchester Castle. Oxford was probably, if not the oldest, one of the most important centers of glass-painting in England, the earliest name being Thomas in the reign of Richard I (died 1199). London must always have been a center of the first importance, and perhaps Southwark was another. Altogether the counties of Norfolk, Suffolk, Essex, and Cambridge could show nearly one hundred glass-painters before the Reformation. It is possible that Chester was also a center of glass-painting.

History of the York school of glass-painting: XV, John Thornton of Coventry and the great east window of York Minster. J. A. Knowles. *Jour. Brit. Soc. Master Glass-Painters*, **6**, 89–99 (1935–36); *Jour. Soc. Glass Tech.*, **19** [76] A430 (1935).—The introduction of John Thornton to York was probably due to the shortage of glass-painters in that city, owing to the Black Death of 1391. In Decem-

ber, 1405, Thornton contracted to execute the great east window (72 ft. high by 32 ft. wide) in three years. According to the agreement he would receive more than £46 in wages and gratuities (at least £230 per annum, present value), and £10 provided the work was satisfactorily completed in the time allowed. That the work was finished in three years is proved by Thornton's device and the date, 1408, at the top of the tracery. Later, Thornton seems to have set up in business for himself in the city, for in 1410 he was made a freeman of York, for which honor he would not be eligible while an employee of the ecclesiastical authorities. For Part XIV see *Ceram. Abs.*, **15** [4] 113 (1936).

Majolica enamel free from lead. L. Vielhaber. *Emailwaren-Ind.*, **12** [45] 362–63; [47] 380–81 (1935).—Directions for producing highly lustrous majolica enamels with bright colors and without additions of lead are given. In majolica enamel, the fluxes used should dissolve the greatest amount of coloring oxides. M.V.C.

Medieval glass in Holme-by-Newark Church, Nottinghampshire. N. Truman. *Jour. Brit. Soc. Master Glass-Painters*, **6**, 80–88 (1935–36); *Jour. Soc. Glass Tech.*, **19** [76] A429 (1935).—T. undertook the complete restoration of this church, which was in a deplorable condition. Not only was the medieval glass treated, but the whole of the clear glazing throughout the church had to be renewed, as every window was broken. A detailed account of the glass is given, with a photograph of the Church. See also *Ceram. Abs.*, **15** [4] 113 (1936).

Old faience of Brussels. H. Nicaise. *Verre & Silicates Ind.*, **6** [26] 457–60 (1935).—A description and historical notes on pieces of old faience of Brussels exhibited at the Art Exposition in Brussels are given. M.V.C.

Pottery sporting cups. G. Bernard Hughes. *Connoisseur*, **96** [409] 146–48 (1935).—When George IV was Prince of Wales, pottery, as other arts, showed many sport types. Chief of all is the stirrup cup modeled as the head of a fox, dog, fish, etc., for the starlight pick-me-up. Derby first produced sporting drinking cups as early as 1790, tawny red in color with realistically modeled eyes, most arresting of all stirrup cups. Staffordshire copied Derby, but used pottery as well as porcelain. Rockingham cups, 1820 to 1842, are of fine white paste, with hard white glaze. Illustrated. E.B.H.

Small kilns for school and studio service: Introduction. C. H. Parmelee. *Bull. Amer. Ceram. Soc.*, **15** [3] 116 (1936). **Super-refractories for small kilns.** B. M. Johnson. *Ibid.*, pp. 116–17. **Syracuse University ceramic kiln.** Mrs. D. P. Randall and C. H. Parmelee. *Ibid.*, pp. 117–20. **Inexpensive oil burner for the amateur potter.** E. A. Solomon. *Ibid.*, pp. 120–22. **Gas-fired kiln designs.** George E. Vance. *Ibid.*, pp. 122–23. **Discussion.** Mabel C. Brady *et al.* *Ibid.*, pp. 123–25.

Swiss craftsmen. Anon. *Design*, **37** [8] 24 (1936).—The art of the Swiss potter in America, though little known, shows a high degree of perfection. Work of a pottery at Bernegg is illustrated. E.B.H.

Tippling through the centuries. Arthur H. Torrey. *Arts & Dec.*, **43** [7] 22–24, 48 (1936).—Early drinking vessels were rarely glass. In Merovingian and Carolingian times there appeared, stemming from the Beowulf drinking horns, a large footless receptacle coming to a point at the bottom, which had to be emptied before set down. Glassmakers evidently did not know how to fashion a foot but adorned the surfaces with blobs of soft glass (which ran down) or "prunts," which facilitated the grip. The Renaissance overcame the heavy Gothic forms, flowering in Italy, and *Façon de Venise*, a funnel shape, both tall and shallow, was popular. Though the drinks of the North demanded sturdier shapes, the lighter, funnel-shaped Venetian models kept them from being mere copies of metal vessels, but thinner and more appropriate. A typical shape was the Roemer, a development adding a foot, a collar-shaped stand for the bowl, the prunts persisting. The best development of the Roemer is the Rhine wine glass, which has a tall slender rod supporting a modest bowl. The discovery of flint glass about 1660 put England in the market lead. Champagne accounts for the shallow bowl, wide-mouth tazza. Collectors now distinguish varieties by stem rather than bowl, since the 18th Century laid emphasis on design of stems. When cutting became popular, it was often indulged in to the extent of losing all form in a mass of sparkling light. Illustrated. E.B.H.

BOOKS

American Art Annual for 1934. Vol. 31. Edited by Katherine Lacy Hoover, Alice Coe McGlauflin, and Florence N. Levy. American Federation of Arts, Washington, D. C., 1935. 528 pp. Price $6.00. This comprehensive annual contains a twenty-page review of the year in art by Frederic Allen Whiting, Jr., a directory of national and regional art organizations, lists of museums and art associations, and a compilation of art schools and art magazines as well as newspapers carrying art notes. Of special interest to ceramic artists are the organizations and schools listed under the index headings of Ceramics and Handicraft Societies. Officers and brief descriptions of the aims of these organizations are given. Meeting dates, membership dues, and types of exhibitions sponsored by the organizations are also listed. Henry H. Smith

Byzantine Art. D. Talbot Rice. Oxford Univ. Press, New York. 255 pp. Price $5.00. Reviewed in *N. Y. Times Book Rev.*, Feb. 16, 1936.—R. discusses the origins of Byzantine art, mosaics, wall paintings, major and minor sculpture, metal work and enamels, textiles, ceramics, glass, and incrustation. The relation of Byzantium to the East, the Slavonic world, and the West is presented illuminatingly. M.V.C.

Excavations at Tepe Gawra. E. A. Speiser. Univ. of Pa. Press, 1935. 200 pp., 86 plates. Price $6.00. Reviewed in *Sci. News Letter*, **28** [760] 288 (1935).—Many successive settlements have been revealed in the excavations at a great mound near the Tigris. S. states that no other site in northern Mesopotamia has shed light on so long a series of prehistoric and early historic occupations. Architecture, pottery, burials, and small objects are described. H.S.

Introduction to Chinese Art. Arnold Silcock. Oxford Univ. Press, New York. 277 pp. Price $2.50. Reviewed in *N. Y. Times Book Rev.*, Jan. 19, 1936.—This book deals with every department of the subject and gives also the condition and history of the different periods. M.V.C.

PATENTS

Designs for:

Ashtray. J. E. SPENCE (Hazel-Atlas Glass Co)., U. S. 98,894, March 10, 1936 (Jan. 10, 1936). N. F. STEUER (Owens-Illinois Glass Co.), U.S. 98,784 and 98,785, March 3, 1936 (Jan. 2, 1936).

Bottle. C. B. GARWOOD (Carr-Lowrey Glass Co.), U. S. 98,859, March 10, 1936 (Jan. 9, 1936). E. J. MCCULLOUGH (Owens-Illinois Glass Co.), U. S. 98,730, Feb. 25, 1936 (Dec. 20, 1935). F. J. PETTY (Ball Brothers Co.), U. S. 98,735, Feb. 25, 1936 (Dec. 18, 1935). GEORGE SMITH, JR. (Olean Glass Co.), U. S. 98,739, Feb. 25, 1936 (Aug. 5, 1935).

Cigarette box. N. F. STEUER (Owens-Illinois Glass Co.), U. S. 98,783, March 3, 1936 (Jan. 2, 1936).

Footed goblet. ELMER BELL (Bryce Brothers Co.), U. S. 98,659, Feb. 25, 1936 (Dec. 9, 1935).

Goblet. A. J. BENNETT. U. S. 98,794, March 3, 1936 (Jan. 13, 1936).

Jar. E. W. FUERST (Owens-Illinois Glass Co.). U. S. 98,857, March 10, 1936 (Jan. 17, 1936).

Plate. A. J. BENNETT, U.S. 98,825, March 10, 1936 (Jan. 13, 1936). YUKIO BUMA (Morimura Bros., Inc.), U. S. 98,827 to 98,849, March 10, 1936 (Jan. 24, 1936).

Cements

Hardening of cement mortars, a chemical or an electrostatic phenomenon? WILLY MACHER. *Montan. Rundschau*, **27** [4] 1–4 (1935).—Tests by L. Jesser over a period of years point to the fact that hardening of concrete does not result from chemical reactions only, but that the hardening processes are greatly affected by electrostatic phenomena during the period of setting. Experiments showed the presence of free ions in electrical nonequilibrium; these produced electromagnetic fields, to which all reactions in the mortar may be ascribed. B.H.S.

Heat and material balances for a rotary cement kiln. W. N. LACEY AND H. WOODS. *Ind. Eng. Chem.*, **27** [4] 379–82 (1935).—Experimentally determined material and heat balances for a dry-process rotary Portland cement kiln are reported. The methods of determination are described, and the necessary calculations are discussed. Illustrated. F.G.H.

Litharge and glycerine mortars. GEORGE W. GLEASON. *Paper Trade Jour.*, 95 [15] 33–36 (1932).—The litharge-glycerine mortars, when made up with Portland cement and sand, are quite plastic. Small changes of glycerine content materially change the consistency. Increase of the glycerine content of the glycerine-water solution used to mix the mortar increases the strength of the set mortar. Richer mixes of litharge appear to have less strength than leaner mixes. Full strength is attained in a relatively short time. Strength and corrosion resistance are frequently related but insufficient data are available to give a definite statement. This mortar is used (1) as a strong, quick-setting cement for placing steel pins in concrete, (2) for cement-tile joints, (3) to join broken concrete, and (4) to embed wall inserts. C.B.J.

Ore cement and iron cement: I–III. S. NAGAI, I. YOSHIDA, AND K. MATSUOKA. *Jour. Soc. Chem. Ind. Japan*, **38** [2] 47–49B; [3] 96–97B; [7] 298–302B (1935).—The results of studies on the preparation and the hydraulic properties of ore cement (Erzzement) and iron cement (Eisenzement), a high iron-oxide special Portland cement, are tabulated. Slag from copper refineries is suitable material for iron cement which has low heat of hydration and high resistibility to sea water. The heating temperature of iron cement must be about 1450° to 1500°C. Calcium fluoride had a considerable effect on the combination of CaO with SiO_2, Al_2O_3, and Fe_2O_3 and lowered the heating temperature. M.V.C.

Seasoning of Portland cement at elevated temperatures. P. S. ROLLER. *Ind. Eng. Chem.*, **28** [3] 362–69 (1936).—Powdered Portland cement absorbed water-vapor from an atmosphere of steam at temperatures above the dew point. The probable advantages of a controlled seasoning process are discussed. Illustrated. See also "Setting—" *Ceram. Abs.*, **14** [11] 269 (1935). F.G.H.

Setting of Portland cement: Rates of contraction and of heat evolution. W. C. L. HEMBON. *Ind. Eng. Chem.*, **27** [6] 694–99 (1935).—Study of the setting of Portland cement paste by means of the rates of contraction of the two phases, cement and water, has shown that there are marked differences in the rates of contraction of cement pastes of approximately the same potential compound composition. Sharp maxima occur in the rate curves of some cements while others manifest no such tendency. The rates of heat evolution of the cement pastes exhibit the same phenomena. A knowledge of the potential compound composition and degree of fineness is insufficient to predict the type of result. Illustrated. F.G.H.

Vibrated concrete: Some considerations on different methods of vibration. ETIENNE TRÈVES. *Génie Civil*, 107 [16] 366–71 (1935).—After showing the advantage of vibrating concrete during filling, T. discusses mechanical means for effecting necessary vibration. J.D.G.

BULLETINS

Gypsum in the Union of South Africa. B. WASSERSTEIN. *Union S. Africa, Dept. Mines, Geol. Series, Bull.* No. 3, 35 pp. (1935). A.H.E.

Hydrates of calcium ferrites. HELLMUTH HOFFMANN. *Mitt. Zementtech. Inst. Tech. Hochschule, Berlin*, No. 52, 63 pp. (1935); abstracted in *Chem. Zentr.*, **i**, 141–42 (1936). M.V.C.

PATENTS

Apparatus for manufacturing and treating cement clinkers. H. S. LEE. U. S. 2,031,049, Feb. 18, 1936 (Sept. 13, 1933).

Cement. LEON MCCULLOCH (Westinghouse Electric & Mfg. Co.). U. S. 2,032,142, Feb. 25, 1936 (Oct. 11, 1934). A cement comprises the reaction products of a mixture of about 62% of powdered flint, about 14% of sodium silicate, about 14% of water, and about 10% of aluminum fluoride.

Method of making hydraulic cement compositions. MAURICE ERNOTTE. U. S. 2,033,233, March 10, 1936 (Jan. 6, 1933). A method of making hydraulic cement composi-

tions comprises the step of admixing with hydraulic cement the by-products from the carbonation of saccharine juices.

Method of producing lightweight plasters. J. C. Best and F. L. Marsh (Best Bros. Keene's Cement Co.). U. S. 2,031,585, Feb. 25, 1936 (Sept. 18, 1933). The method of producing lightweight plaster includes calcining crushed or ground gypsum rock, mixing the calcined material with water, adding an accelerating agent to the mixture, agitating the wet mixture until it has recrystallized in a finer particle size, and recalcining the material.

Process of manufacturing Portland cement. L. A. Dahl and W. C. Hanna (California Portland Cement Co.). U. S. 2,032,347, March 3, 1936 (March 14, 1933).

Process of preparing Portland cement raw mixtures. L. A. Dahl and W. C. Hanna (California Portland Cement Co.). U. S. 2,032,346, March 3, 1936 (March 14, 1933).

Enamel

Acid pickling of ferrous materials. Anon. *Wire Ind.*, **2**, 245–47 (1935); abstracted in *Jour. Iron Steel Inst.*, **132** [2] 447 (1935).—The mechanism of pickling is briefly touched on, and attention is then directed to the use of inhibitors. These are divided into two classes, (*a*) foaming and (*b*) nonfoaming. The former type prevents spraying and assists in holding up surface scum; the latter is adopted where the use of a foam is considered objectionable. Both types are equally effective.

Acid-resisting overglaze. Anon. *Amer. Enameler*, **8** [6] 14 (1935).—The Porcelain Enamel & Mfg. Co. clear, acid-resisting overglaze is said to prove particularly helpful to porcelain-enamel sign manufacturers because it has a practically stainless surface and imparts greater depth of color and luster to porcelain enamel. J.H.S.

Briggs sanitary ware of porcelain steel. Anon. *Ceram. Ind.*, **26** [2] 112–16 (1936).—Illustrated. E.J.V.

Cleaning enamel shapes. Murray C. Gautsch. *Metal Cleaning & Finishing*, **8** [2] 81–84 (1936).—With enameling stocks that form without abnormal strains, the necessity for annealing has been greatly reduced, and an increased use of degreasing baths for removing the oil film has resulted. The type of degreasing bath used depends on the kind of die lubricant used; the strength of the bath is determined by the type of cleaner, the type of die lubricant, and the amount of oil to be removed. Pickling consists in treating sheet steel with hydrochloric or sulfuric acid to remove iron oxide and slag scale. Inhibitors are colloidal organic compounds, their chief function being mechanical, *i.e.*, forming foam through which the hydrogen and steam must work their way, thus leaving behind acid particles which ordinarily are carried away with the hydrogen and steam. After degreasing and pickling, the ware must be thoroughly washed in water. A neutralizing bath has two purposes, *viz.*, (1) to neutralize acid clinging to the surface and in the pores of the iron and (2) to leave a slight film on the ware. This film acts as a passivity agent, preventing oxidation of the iron before the ware is enameled and excess oxidation during the preheating in ground-coat firing. The different chemicals used in neutralizing baths are discussed. E.J.V.

Composition of enamels: I, Acid-resisting enamels. L. Vielhaber. *Emaillerie*, **3** [8] 21–25 (1935).—The results of A. I. Andrews (*Jour. Amer. Ceram. Soc.*, **13** [6] 411–26 (1930)) on limiting compositions are quoted. V. draws the conclusion that such enamels should contain at least 43% silica, with a maximum limit content of the following compounds: 5 alumina, 2 fluorspar, and 3% magnesia and barium oxide together, the boracic acid to lead oxide ratio being 20 to 25%, the zinc oxide content 4 to 8%, and clay as small as possible. Antimony oxide is the opacifier. TiO_2 or ZnO_2 may take the place of SiO_2. Formulas are given. **II, Copper and brass enamels.** *Ibid.*, pp. 25–27.—Data are given for various low melting enamels whose compositions are given with regard to their use. See also *Ceram. Abs.*, **15** [1] 8 (1936). M.D.-B.

Continuous production at the Caloric Gas Stove Works. Anon. *Amer. Enameler*, **8** [7] 3 (1935).—This plant represents the latest developments in the efficient manufacture of ranges on a straight-line, mass-production basis, operating 24 hours a day on three shifts. The plant covers five acres and employs 650 persons. J.H.S.

Design of sheet-metal parts for enameled ranges. H. H. Holscher. *Ceram. Ind.*, **26** [2] 124–32 (1936).—This treatise on the design of sheet-metal parts to be covered with porcelain enamel is a generalized treatment of design fundamentals, precautions, and details to aid in the fabrication and finishing. Illustrated. E.J.V.

Diffusion of hydrogen in pickling iron sheets. H. Bablik. *Korrosion & Metallschutz*, **11**, 169–72 (1935).—Diffusion is increased by the presence of H_2S in the pickling acid. By reducing the sulfur many difficulties due to hydrogen absorption, such as gray sheet, are avoided. J.B.A.

Effect of mill additions on the thermal expansion of sheet-iron ground-coat enamels. R. L. Fellows and E. E. Howe. *Jour. Amer. Ceram. Soc.*, **19** [4] 109–11 (1936).

Enameling in the electric furnace. Anon. *Sci. et Ind. (Electricité)*, **19** [4] 167 (1935).—Operations for white enameling of hollow steel plate ware are given. The importance of the heating method in preventing defects is pointed out. Electric heating is particularly suitable for this work. In the nonelectric furnaces commonly used, combustion gases travel outside of a muffle. In electric furnaces the muffle is eliminated, the output being consequently greater for a given hearth area. Heating resistors are placed to supply heat on all sides of the ware; heating on the support side is important in order to bring the supports to the correct temperature. Electric furnaces can be thoroughly insulated; consequently work is easier for the furnace man. Temperature control is automatic. Temperatures can be controlled within a few degrees, which is quite impossible with fuel furnaces. The maintenance cost is low, a set of resistance grids allowing 30,000 hr. work. In France electric heating in enameling furnaces is undeveloped owing to high current cost. Continuous furnaces are more economical than periodic furnaces but can be resorted to only for enameling steel plates such as parts of refrigerator cabinets made in repetition work. F.R.

Evolution of Shell truck signs. E. Gidlow. *Better*

Enameling, **7** [2] 8–10 (1936).—G. traces the evolution of the signs on Shell Oil Co. trucks from the painted wooden signs used in 1929 to the present individually mounted letters of porcelain enamel. Illustrated. E.J.V.

Experiments in the development of a sand-abrasion machine. G. H. SPENCER-STRONG. *Jour. Amer. Ceram. Soc.*, **19** [4] 112–15 (1936).

FHA and porcelain enameling. ROBERT B. SMITH. *Amer. Enameler*, **8** [8] 5 (1935).—Home modernization, as encouraged by the Federal Housing Administration, presupposes the extensive use of enameled furnishings. J.H.S.

Further data on enamel adherence. KARL KAUTZ. *Jour. Amer. Ceram. Soc.*, **19** [4] 93–108 (1936).

History, development, and manufacture of glass-lined steel equipment for the brewing and kindred industries. S. W. MCCANN. *Jour. Inst. Brew.*, **41**, 403–406 (1935); *Brit. Chem. Abs.—B.*, **54**, 1048 (Nov. 22 and 29, 1935).

Importance of screen care in enamel-fineness control. G. H. SPENCER-STRONG. *Amer. Enameler*, **8** [8] 3 (1935).—Fineness of grinding of porcelain enamel slips is important, but the practical objection to the fineness test as used at present is not in the theory but in the materials with which the test must be carried on. A 200-mesh sieve is a delicate and relatively expensive tool for everyday use. In the past, too much emphasis has been placed on the method of procedure of the test and too little upon means of keeping the results comparably constant. It must be remembered that a fine-mesh sieve depends for its function upon the size of openings between the woven bronze wires. A fine sieve naturally requires fine wires and these stretch in time, changing the size of the openings. The fine wires are easily broken and, rather than discard a valuable sieve, the holes are soldered. Enamel glass is forced between the wires, plugging some openings and warping the adjoining ones. As a result, after a few weeks of use in mill-room control, the average size of the sieve openings has been changed and the results of tests run on the screen may be several per cent in error. The fine-mesh sieve is an unsatisfactory tool for use in daily control of enamel fineness, but at present is the best tool available and must be used, if fineness tests are to be run. If the weaknesses of the sieve are kept in mind and guarded against, the fineness test will prove invaluable; if ignored, it may become the costly seat of numerous plant troubles. J.H.S.

Inhibitors. K. B. LEWIS. *Wire & Wire Prod.*, **10**, 236–37, 243 (1935); abstracted in *Jour. Iron Steel Inst.*, **132** [2] 447 (1935).—Some results obtained by foreign investigators in the field of wire pickling are discussed, brief reference being made to the effect of hydrogen and of inhibitors.

Materials producing the best opacification of enamel. H. LANG. *Glashütte*, **65** [45] 705–707 (1935).—The use and effect of various opacifiers, such as tin oxide, bone ash (no longer used), kaolin and clay, feldspar, cryolite, sodium fluosilicate, fluorspar, and antimony, are discussed. L. concludes that the most efficient opacifier for white enamel is antimony (Sb_2O_3 is poisonous, but Sb_2O_5 is harmless) with additions of cerous oxide which is added to the mill. Cerous oxide produces a lustrous enamel. M.V.C.

Modern electrolytic pickling processes. O. UNGERSBOCK. *Z. Oesterreichischen Ing. & Architekten Vereines*, **87**, 116–17 (1935); abstracted in *Jour. Iron Steel Inst.*, **132** [2] 446 (1935).—After explaining briefly the reactions at the electrodes when electric current is passed through them and an electrolyte into which they dip, U. gives a short account of electrolytic pickling without direct contact of the articles with the electrodes. The objects are placed between the electroden and, as the current follows the path of least resistance, practically all of it enters one side of the article and leaves by the other. By rotating the article the advantages of the reversal of polarity are obtained. The process is more rapid than the ordinary pickling process and does not slow down with time. The greater plant cost is compensated for by the lower operating costs due to the shorter time.

New York-Cleveland artist completes new porcelain enameled work. R. H. HELMER. *Better Enameling*, **7** [2] 13–14 (1936).—Russel Barnett Aitken, widely known as a ceramic sculptor, produced a large porcelain enamel screen, 9 ft. high by 12 ft. wide, in four 3-ft. panels, using an African devil dance as the decorative motif, in six days of intensive work at the W. A. Barrows Porcelain Enamel Co., Cincinnati, Ohio. Using regular commercial acid-resisting frit on copper and colored enamels, A. makes a design on the enamel before the firing process begins. Illustrated. E.J.V.

News from a million kitchens. KATHLEEN ROBERTSON. *Amer. Enameler*, **8** [7] 11 (1935). J.H.S.

Nickel bath after pickling. L. VIELHABER. *Emailwaren-Ind.*, **12** [44] 353–54 (1935).—Data on the concentration of nickel baths (for the adhering oxide), its control, and use after pickling are discussed. M.V.C.

Porcelain enameling furnaces: I, Box-type and auxiliary equipment. ANON. *Better Enameling*, **7** [2] 15–17 (1936).—A general description of the muffle-type furnace is presented. The fuels used may be coal, gas, or oil, but if coal is used the furnace must be constructed for that fuel, with a large combustion chamber under the muffle floor to provide space for burning the crude fuel. The intermittent-type box furnace is similar but has no muffle. The gas radiant-tube type furnace is a recent innovation. The electric furnace needs no muffle and is more costly to operate, but temperatures are readily controlled and other points are in its favor. Auxiliary equipment consists of a loading fork or speed fork, firing bars, hand forks for removing the ware from the loading equipment, door-lifting equipment, timing clock, etc. Illustrated. E.J.V.

Processes taking place during the melting of enamel. L. VIELHABER. *Emailwaren-Ind.*, **12** [51] 404–405 (1935).—It is necessary to protect the enamel from water-vapors and CO_2 developed from borax and saltpeter during melting. Fe_2O_3 from the refractories of the tank can produce discolorations in the enamel. M.V.C.

Temperature and the "black-edge" problem. G. H. SPENCER-STRONG. *Amer. Enameler*, **8** [6] 3 (1935).—All enamel frits are water-soluble to a limited degree, and the most important soluble ingredient is soda. If the temperature of the enamel is raised, the alkali solution is increased quite rapidly. Thus, the presence of excess alkali, due to increased solution in warm weather, in either ground coat or black edge may cause blistering in the black edge. The defect may be minimized by the cooling of the enamels (both ground coat and black edge) during milling, in stor-

age, and during application, or, in the case of enamels which have been stored in a warm place, by removal of the excess mill liquor. J.H.S.

Temperature control in the enameling industry. HENRY CRAVEN. *Amer. Enameler*, **8** [9] 3 (1935).—Methods and apparatus for temperature control are described. J.H.S.

Two-colored cast-iron enamels in one firing. ANON. *Glashütte*, **65** [48] 755–57 (1935). M.V.C.

PATENTS

Methods of producing decorative surfaces. KARL TÖRK (Porcelain Enamel & Mfg. Co.). U. S. 2,032,236, Feb. 25, 1936 (Jan. 28, 1933). The process of producing on a base having a copper surface an article having a gold-like appearing vitreous enamel surface comprises producing an acid-resisting vitreous enamel capable of forming on firing an enamel of sufficient transparency to light rays so that the color of the base is visually apparent through the enamel, and containing a metallic oxide selected from the group consisting of iron oxide, nickel oxide, and manganese oxide functioning to impart to the enamel a potential color component capable of combining with the copper color component of the base to produce the gold appearance, applying to the base a thin coating of the enamel, and firing to produce the gold-like color, the color of the base being visually apparent through the enamel.

Vitreous enamel opacifier. W. J. HARSHAW AND W. D. STILLWELL (HARSHAW CHEMICAL CO.). U. S. 2,033,707, March 10, 1936 (April 16, 1934). A vitreous enamel white opacifying agent has the general formula $2M^{II}O \cdot 3R^{IV}O_2 \cdot Sb_2O_5$, in which R is titanium or zirconium and M is zinc, barium, calcium, beryllium, tin, strontium, magnesium, aluminum, cerium, manganese, lead, copper, or an alkali metal in partial substitution of the aforesaid metals.

Glass

Activated adsorption of gases in glassy materials and conclusions as to the degasification of glass surfaces. PRETTRE. *Documentat. Sci.*, **4**, 241–49 (1935); abstracted in *Chem. Zentr.*, ii, 3894 (1935).—On the basis of studies made by Benton and White, P. explains the effect of the temperature on adsorption. Systematic researches of Williamson (*Ceram. Abs.*, **13** [1] 9 (1934)) with H_2-quartz glass and H_2-Pyrex-brand glass showed that the velocity and amount of adsorption increase greatly with the temperature. CO_2 and steam behave in the same way as H_2O. P. concludes that the most suitable temperature at which H_2O is removed from glassware is 300°, when the rate of adsorption and desorption is the greatest. M.V.C.

Advance in the safety-glass industry. ANON. *Chem.-Metall. Z.*, **24** [101] 1609 (1934).—The following are possibilities in glass manufacture for securing greater adaptability by heightening the service load: (1) increasing the thickness of intermediate layers, formerly 0.5 mm., to at least 2 mm.; (2) utilizing stronger panes of glass; (3) using more than two panes of glass and correspondingly more intermediate layers; (4) embedding wire glass in ordinary glass, or (5) making a wire-glass inlay; and (6) using hardened glass. These possibilities have already been realized. The heat and pressure of former working processes are now applied in a vacuum, simultaneously. Pressed-in grooves in glass covers act as canals in removing the solvent vapors. A recipe for the application of wire glass to safety glass uses wire glass 7.4 mm. thick, wire diameter 0.5 mm., width of net about 6 mm., intermediate layer of polyacrylic acid 0.6 in strength, and window glass 2.4 mm. thick. Such glass is capable of the greatest load and is adaptable to special purposes. In pressure tests it sustained an absolute gas density pressure up to 800 g./sq. cm. Following this, a pressure drop to 600 g./sq. cm. was observed for several minutes, and this held for a short time. In pressure-loading of wired safety glass from the side, fissures occur at an excess pressure of 1050 g./sq. cm. and they transfer complete gas densities. Increasing the acrylic ester of the intermediate layer hitherto in use from 0.5 mm. to 2 mm. in thickness will permit more than 50% increase in the resistance power of a given safety glass. Safety glass for special purposes, *e.g.*, shot-proof glass, has aroused great interest. The objectionable, unstable celluloid intermediate layers have been replaced by permanent intermediate materials (polymerization combinations) remarkable for their higher adhesion. Manufacture of shot-proof, armor-plate cruiser glass has been simplified and is consequently cheaper. It is chiefly distinguished from the many-layered safety glass used in vehicles and boats by greatly increased thickness and multiplication of the layers. Commercial strength of layers for such special purposes is 18 to 24 mm., as compared with the average plate-glass thickness of 12 to 15 mm. Armored glass has its panes symmetrically arranged as to thickness, the thinnest layers being toward the outside. Maximum protective effect is thus secured. The discharged projectile goes through the thickest part of several layers and its energy is absorbed; it sticks fast in the glass, is deformed, and finally falls out of the pane. The varying oscillations it has set up in the glass layers with their diverse strength, increase their resistance. They accomplish extensive destruction of energy and minimize the dangers of split. *Ibid.*, [103] 1642–43.—Armor-plate glass, in perpendicular set-up, 11 to 12 mm. thick, has proved shot-proof to a complete gun discharge. The panes stood fast when tested by 7.5 pistol shots at varying distances; the surfaces struck crumbled often, 2 mm. on the average, and the glass took on ray-like cracks without actual splitting. A 22-mm., strong armor-plate glass at 3-mm. range, with a 9-mm. steel-covered charge, will have only its surface layers smashed, these being relatively thin. The difficulties in producing this kind of safety glass are fewer than those surmounted in securing its raw materials. The usual machine-made glass is so much cheaper to manufacture that business firms continue to employ the customary plate glass, unless special strain is to be put upon their glass. K.R.

Alloy orifice in refractory dies gives uniform glass flow for lamp bases. ANON. *Ceram. Age*, **26** [3] 99–100 (1935). An alloy lining, 0.030 in. thick and composed of 90% platinum and 10% rhodium, is inserted in an Alundum refractory support to form a die which gives a uniform flow of glass for lamp bases. F.G.H.

Application possibilities of hollow glasses. G. EHLERS.

RTA-Nachrichten, **15** [22] 3–4 (1935); abstracted in *Referat. Silikatliteratur*, No. 1932 (1935); *Eng. Progress*, **16** [12] 307–308 (1935).—Because of the great improvement in the chemical and physical properties, especially strength, of hollow glass, new uses for it are discussed, such as for hot-water pipes, electric hot-water accumulators, beer conduits, in refrigerators, vacuum pipes, etc. The uses of stressed glass are mentioned. M.V.C.+J.L.G.

Blackening of glasses by short-wave rays. ANON. *Keram. Rundschau*, **43** [19] 219–20 (1935).—An outline of theories presented by different investigators is given. The effect of the rays from radium, of X-rays, and of ultra-violet rays is described. A bibliography covers the period from 1912 to 1931. F.E.V.

Course in glassmaking. ANON. *Verre & Silicates Ind.*, **6** [26] 460–63 (1935).—The operation of a gas generator is discussed. See *Ceram. Abs.*, **15** [4] 117 (1936). M.V.C.

Curious property of glass. R. D. *Verre & Silicates Ind.*, **6** [25] 445 (1935).—Vitreous surfaces (glass, fused silica, glazed porcelain) have a special action on processes and the rate of certain chemical reactions, in which an initial chemical transformation produces intermediate products with a great chemical activity (accelerated molecules, atoms, or radicals) which react energetically with other substances present and which are regenerated during the reactions. Spontaneous ignition and increased temperature of reactions in contact with a surface of Pyrex-brand glass have been studied, but it remains to be determined in what way the reactions differ which are effected in the presence of these different surfaces. M.V.C.

Decoloration of glass. A. N. DAUVALTER. *Keram. i Steklo*, **11** [9] 1–9 (1935).—The effect of glass colorizers, such as Fe_2O_3, FeO, Cr_2O_3, CrO_3, FeS, FeSe, NiSe, NiS, and TiO_2, is discussed. There are five ways to eliminate or weaken the effect of these pigments: (1) the selection of pure and high-grade raw materials; (2) elimination of pigments from the raw materials; (3) their elimination from the glass; (4) changing pigments into discolored or weakly colored compounds; (5) coloring glass into a supplementary color which destroys the original color. The theories of chemical and physical decoloration are discussed in detail. The chief properties of a well-decolorized glass are (1) a complete lack of color tones and (2) transparency (purity, luster). The first condition is obtained with any pair of red and blue physical decolorizers, exact determination of their amounts, and conditions of melting. The second property is physically determined by the coefficient of absorption produced by decolorizers. Any decolorizer, together with the injurious admixtures, has the effect of absorbing light. The absorption of light is explained, and the effect of physical and chemical decolorizers is discussed. Directions for decolorizing glass are given. M.V.C.

Defects in optical glass. A. C. S. VAN HEEL. *Ingenieur*, **50**, 29–30, 31–32 (1935); abstracted in *Chem. Zentr.*, **i**, 139 (1936).—A discussion is given of the required properties of optical glass and of methods used to obtain them. Homogeneity, isotropy, durability, refraction of light, temperature effects, working, and secondary spectrum are discussed. M.V.C.

Effect of alumina on the softening temperature and viscosity of glass. C. W. PARMELEE AND A. E. BADGER. *Glass Ind.*, **17** [3] 85–86 (1936).—A series of glasses consisting of 17.4 Na_2O, 10.1 CaO, and 72.5% SiO_2 and Al_2O_3, with Al_2O_3 ranging from 0 to 10%, was prepared by melting in platinum crucibles. The softening temperatures of these glasses, measured by an interferometric method, may be represented by the straight-line equation, $t = 582 + 3.2p$, where t is softening point in °C and p is per cent of Al_2O_3 in the glass. A correlation between softening temperature and viscosity was made on the basis of Twyman's law of viscosity changes in the annealing range. From the latter standpoint, the viscosities of the glasses at any constant temperature, when Twyman's law holds, may be represented by the relation $V_p = V_o\,(1.28)^p$, where V_p is viscosity of any glass of the series, V_o the viscosity of the base glass, and p the per cent of Al_2O_3. Illustrated. E.J.V.

Electric annealing furnaces and their heating elements. W. ROHN. *Elektrowärme*, **6** [1] 17–20 (1936).—Electric annealing furnaces are divided into five groups, according to their operating temperature ranges: (1) up to 800°C, with heating elements of alloys with 15 to 20% Cr, 30 to 20% Ni, and the remainder Fe; (2) 800° to 950°, with elements of 15 to 20% Cr, 10 to 20% Fe, remainder Ni; (3) 950° to 1100°, with Fe-free Ni-Cr elements of about 20% Cr and 80% Ni; (4) 1100° to 1250°, elements of 20 to 30% Cr, 6 to 4% Al + Si, remainder Fe; (5) from 1250° to 1450°C; here ceramic heating elements of silicon carbide must be used. The influence of furnace atmosphere, temperature fluctuations, and dimensions of the heating elements on their life, and economical considerations in the investment of higher or lower first costs of a plant are discussed. M.H.

Glass as a dielectric. G. W. MOREY. *Jour. Franklin Inst.*, **219**, 315–30 (1935).—Like other dielectrics, volume and surface conductivity must be separately considered. Part of the electrical conductivity of glass is dependent upon a condensed film of moisture on the surface. There is no agreement as to whether the film is mono- or polymolecular, is adsorbed, or is in surface solution. The dependence of volume and surface conductivity on variables such as relative humidity, temperature, composition of glass specimen, frequency, etc., is discussed, and experimental results are graphed and explained. The complication afforded by dielectric absorption in the measurement of resistivity at low temperatures is probed. The connection between power factor and electrical conductivity and the factors governing these are briefly discussed. P.T.C.

Glassmelting pot furnace of N. I. Ivanovskii. F. S. SEMENOV. *Keram. i Steklo*, **11** [10] 24–25 (1935).—Details of construction and operation of a pot furnace for melting glass are dealt with. The furnace is being used with success for melting optical and technical glass. M.V.C.

Glass permeable to ultra-violet rays. KARL GENTIL. *Umschau*, **39**, 341–43 (1935); abstracted in *Chem. Zentr.*, **ii**, 3812 (1935).—The permeability to ultra-violet rays of phosphate glasses of the I. G. is nearly equal to that of quartz glass. They are much superior to ultra-violet glasses with a silica base. Data on the permeability of these glasses in different regions of the spectrum are given. M.V.C.

Glass rolls up like rag rug. ASSOCIATED PRESS.

Chicago Daily Tribune (March 18, 1936).—A new safety glass developed, in the Pittsburgh Plate Glass Co. laboratories and those of the Carbide and Carbon Chemical Corp., as a refinement of the present familiar shatterproof glass, consists of two sheets of "real" glass, each sheet just under $^1/_8$ in. thick, with a plastic between, $^1/_{100}$ in. thick. The commercial product will use half this thickness of plastic. The rosin, which binds the glass sheets together even after they are broken to bits, stretches several times its own length, and consists of vinyl, a product of Mellon Institute. After the glass surfaces have been smashed thoroughly, the material rolls up like a rug. At 10° below zero it is approximately 10 times as resistant to breaks as other types of safety glass. Low-temperature brittleness has been both an ideal and a problem to safety-glass manufacturers. The glass can be cut without heating. The ordinary method of cutting glass is first used on it, then it is stretched so that a razor blade can be inserted to cut the plastic. As a publicity test, a mule kicked a complete panel of it out of its frame, all in the one piece. A football player "bucked" up against a sheet of it, whereupon it bulged out 6 in., then sprang back into place. Finally a performer from "Jumbo" hung to a shattered piece, while it stretched like elastic, slowly regaining its shape when released. The Pittsburgh Plate Glass Co. and the Libby-Owens-Ford Co. are to manufacture this new safety glass for commercial uses. K.R.

Glass silk for insulation of heat and sound. A. L. Forster. *Trans. Liverpool Eng. Soc.*, **56**, 159–74 (1935); abstracted in *Jour. Iron Steel Inst.*, **132** [2] 332 (1935).—F. gives an account of the nature of glass silk and of its properties as a heat insulator compared with those of other heat-insulating media.

Lime in container batches. Anon. *Glass Ind.*, **17** [3] 92 (1936).—The points in the use of raw lime *vs.* calcined lime and for high calcium lime *vs.* dolomitic lime are listed. Today lime is being introduced in mixtures of the different kinds or in combinations of all four, because the various types of lime possess different actions and give special properties to the melt or the finished glass. These points are discussed in detail. E.J.V.

One-layer safety glass. A. I. Lubich, G. P. Petrov, and S. S. Gamburg. *Keram. i Steklo*, **11** [9] 21–23 (1935).—Data on properties of German and French chilled safety one-layer glasses and those manufactured in the U.S.S.R. are analyzed and compared. M.V.C.

Polishing flat glass. N. P. Anders. *Keram. i Steklo*, **11** [9] 23–27 (1935).—A detailed discussion is given of methods used for polishing flat glass in the U.S.S.R. M.V.C.

Purification of sands. F. W. Adams. Read before Soc. Glass Tech., Sheffield, England, April, 1935; abstracted in *Engineering*, **139** [3615] 442 (1935). H.E.S.

Pyrex-brand Top-of-Stove ware. J. C. Hostetter. *Ceram. Ind.*, **26** [2] 99–100 (1936).—As the result of 36,000 tests made on 1500 different kinds of glass there has been produced a glass sufficiently fluid at high temperatures to melt and fabricate yet of a low coefficient of expansion and high strain point, so that when specially treated it has a heat resistance satisfactory for use on top of the stove. It is said to be lighter in weight and far more heat resistant than Pyrex-brand ovenware. Illustrated. E.J.V.

Resistance of glass to fluorine. Yen Ki-Heng, A. Violet, and E. Darmois. *Documentat. Sci.*, **4**, 65–69 (1935); abstracted in *Chem. Zentr.*, **ii**, 3965 (1935).—Figures of relative resistivity of a series of glasses, such as quartz, Pyrex-brand, Sibor, Cavalier, 202, and chemical apparatus glass, in relation to temperature and surface, are given. M.V.C.

Sandwich glass: II. Alexander Silverman. *Glass Ind.*, **17** [3] 93–96 (1936).—Records of batches used in the production of opal and alabaster glass in the Sandwich factory show a knowledge of a considerable variety of these glasses. The formulas are listed and discussed. For Part I see *Ceram. Abs.*, **15** [4] 118 (1936). E.J.V.

Simple method for testing quartz sand. Th. Shauer. *Sprechsaal*, **68** [40] 616–18 (1935).—Most German sand deposits used in the glass industry are found with lignite deposits and contain small quantities of impurities, *e.g.*, lignite, ferric oxide, alumina, and titanium oxide. Other impurities, such as potassium salts, pyrites, and calcium minerals, are removed by elutriation and sifting. Details of sampling and treating are given. M.V.C.

Sins against glass. Th. Ziehner. *Glas & App.*, **16** [25] 237–38; [26] 247–48 (1935).—The factors influencing the mechanical strength of glass are discussed. Neglecting to observe the simplest rules for (1) avoiding interior stresses, (2) notch effects of surface conditions, and (3) proper shaping to avoid sudden changes in section and thus sudden change of stresses is, in the majority of cases, the cause of failures in the operation and use of glass. Examples illustrate such defects. M.H.

Streaks in optical glass. N. Tudorovskaya. *Tech. Physics* [U.S.S.R.], **1**, 212–20 (1934); abstracted in *Chem. Zentr.*, **ii**, 3965 (1935).—T. discusses methods used for the detection and determination of the size of streaks in glass; 97% of the measured streaks had a lower index of refraction than the surrounding glass. M.V.C.

Surface dulling of Albatrin glass and its effect on melting pots. Egon Arnot. *Sprechsaal*, **68** [39] 601–602 (1935).—Reasons for the dulling of the surface of opal or Albatrin glasses and suggestions for the elimination of these defects are discussed. Cases from practice are described, and the structure and nature of refractories for pots to increase their resistance to the corroding effect of glass melts are dealt with. M.V.C.

Tank furnaces with separated compartments. S. S. Berman. *Keram. i Steklo*, **11** [10] 10–16 (1935).—B. discusses (1) the thermal characteristics of processes occurring during the formation of glass, (2) division of tank furnaces into separate zones, and (3) various systems of furnaces (Siemens furnace with continuous operation, American furnaces, etc.). M.V.C.

BOOKS AND BULLETINS

Annealing Industrial Glasses. S. G. Lioznyanskaya and S. I. Iofe. State Sci.-Research Inst. of Glass. State Pub. House of Light Ind., Moscow, 1935. 68 pp., 27 figs. Price 1R 25k. The appearance and removal of tensions in glass, optical and mechanical methods of determining the annealing temperature, the influence of glass-forming oxides on this temperature, the annealing schedule, and its calculation and influence on the properties of glass are discussed. Practical data on the determination of the anneal-

ing temperature, its control, and basic principles of correct annealing and annealing furnaces are given.

S. I. PERKAL

Apparatus and Methods of Physico-Technical Control of Glass Manufacture. STATE SCI.-RESEARCH INST. of GLASS. State Pub. House of Light Ind., Moscow, 1935. 63 pp. Price 1R 5k. This symposium of papers deals with the determination of the mechanical, thermal, constitutional, and optical properties of glass. A range of methods developed by the Institute is included. S. I. PERKAL

German limestone and dolomites in the production of glass. W. DIENEMANN, H. HEINRICHS, R. SCHMIDT, AND L. SPRINGER. *Fachausschuss-Ber.* [Deut. Glastech. Ges.], No. 32, 12 pp. (1935); abstracted in *Referat. Silikatliteratur*, No. 2042 (1935).—German deposits of various kinds of limestones and dolomites, and their classification, properties, composition, and use in the production of glass are discussed in detail. M.V.C.

Optical study of the constitution of solutions and glasses. WOLDEMAR WEYL. *Beiheft Angew. Chem. & Chem. Fabrik*, No. 18, 34 pp. (1935); abstracted in *Chem. Zentr.*, i, 594–95 (1936).—Attempts to detect constitutional changes in solutions and glasses from absorption spectra of colored ions are described. The colored glasses studied included Fe glasses, Mn glasses, and Cr, Ni, and Cu glasses. M.V.C.

Thermal insulation of glass furnaces. W. FRIEDMANN AND W. GIEGERICH. *Fachausschuss-Ber.* [Deut. Glastech. Ges.], No. 33, 18 pp. (1935); abstracted in *Referat. Silikatliteratur*, No. 2046 (1935).—The effect of various insulating materials, such as fired insulating brick, kieselguhr and moler earth, slag and mineral wool, insulating concrete, and Alfol insulation, is discussed in detail. Data on the insulation of glass furnaces with these materials are given. M.V.C.

PATENTS

Apparatus for case-hardening glass. H. J. GALEY (Pittsburgh Plate Glass Co.). U. S. 2,032,008, Feb. 25, 1936 (Oct. 13, 1934).

Apparatus for feeding molten glass. G. E. HOWARD (Hartford-Empire Co.). U. S. 2,033,075, March 3, 1936 (Oct. 24, 1932).

Apparatus for grinding, beveling, and polishing the edges of glass sheets. K. A. WEBER. Ger. 599,547, Feb. 28, 1930, Kl. 67a, 15; *Keram. Rundschau*, **43** [4] 45 (1935). R.W.D.

Apparatus for making flat glass. FREDERICK GELSTHARP AND J. H. FOX (Pittsburgh Plate Glass Co.). U. S. 2,032,009, Feb. 25, 1936 (Aug. 14, 1934).

Decorating glassware. W. BECKER. Ger. 617,894, July 15, 1935 (Sept. 10, 1934), VI/32*b*, Gp. 10; *Jour. Soc. Glass Tech.*, **19** [76] A396 (1935).—Glassware with a surface consisting of raised and sunk portions, *e.g.*, with a pattern in relief, is given a thin coating of metal, as by silvering, and then that portion of the layer on the raised portions is removed.

Drawing sheet glass. N. V. HOLLANDSCHE MAATSCHAPPIJ VOOR DE VERVAARDIGING VAN GLAS. Ger. 617,337, July 25, 1935 (June 6, 1933), VI/32*a*, Gp. 23_a; *Jour. Soc. Glass Tech.*, **19** [76] A388 (1935).—In a process for drawing sheet glass from a bar located in a drawing chamber, the bar extends as a partition across the chamber and to the full depth thereof, glass being fed from the refining end of the tank to either end of the chamber.

Flowerpots. UNITED GLASS BOTTLE MANUFACTURERS, LTD., AND H. J. JUDD. Brit. 442,171, Feb. 19, 1936 (Sept. 28, 1934).

Glass-beveling machine. R. B. SMITH. U. S. 2,031,743, Feb. 25, 1936 (March 27, 1934).

Glass container and method of producing. F. L. DARLING (Anchor Cap & Closure Corp.). U. S. 2,032,920, March 3, 1936 (Dec. 19, 1932).

Glass-cutting apparatus. J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 2,033,188, March 10, 1936 (April 5, 1933).

Glass-feeding device. J. W. HARDING. U. S. 2,031,413, Feb. 18, 1936 (March 10, 1934).

Glass-to-metal seals. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 442,417, Feb. 19, 1936 (Sept. 1, 1934).

Glass permeable to ultra-violet rays. WALDEMAR KAUFMANN AND EVERHARD BUNGARTZ (I. G. Farbenind. A.-G.). U. S. 2,031,958, Feb. 25, 1936 (March 24, 1933). As a composition of matter, a glass batch having as its chief constituent barium metaphosphate and as an addition agent the metaphosphate of at least one alkaline earth metal, the glass batch yielding a glass characterized in that it is permeable to ultra-violet rays and resistant to water.

Glassware and process of making. CORNING GLASS WORKS. Brit. 442,526, Feb. 26, 1936 (March 19, 1934).

Guide or support for molten glass. C. A. WELLER (Baker & Co., Inc., and Westinghouse Electric & Mfg. Co.). U. S. 2,031,083, Feb. 18, 1936 (Jan. 21, 1933).

Handling sheet glass at cutting end of leer. GLACERIES DE LA SAMBRE SOC. ANON. Ger. 614,412, May 23, 1935 (Dec. 24, 1931), VI/32*a*, Gp. 29; *Jour. Soc. Glass Tech.*, **19** [76] A389 (1935).—In a leer in which sheet glass is conveyed by rollers arranged in several sections, the drive to the open end where the sheet comes to the cutting station is manually or automatically coupled to that of the adjacent set in order to give control of the position of the sheet.

Laminated glass. W. O. HERRMANN AND ERICH BAUM (Chemische Forschungsges., m. b. H.). U. S. 2,033,377, March 10, 1936 (March 8, 1932).

Laminated glass and process for preparing. H. T. NEHER (Röhm & Haas Co.). U. S. 2,032,663, March 3, 1936 (May 25, 1932).

Leer. E. C. STEWART (Tygart Valley Glass Co.). U. S. 2,033,261, March 10, 1936 (Jan. 30, 1935).

Leer stacking or feeding mechanism. UNITED GLASS BOTTLE MANUFACTURERS, LTD., AND E. P. DORMAN. Brit. 441,546 and 441,681, Feb. 5, 1936 (June 20, 1934).

Lens. EDWARD CULVER AND A. H. EMERSON (United Kingdom Optical Co., Ltd.). U. S. 2,032,796, March 3, 1936 (May 23, 1930; April 6, 1933).

Lens for head lamps, etc. J. L. KOUBEK (General Motors Corp.). U. S. 2,033,382, March 10, 1936 (July 7, 1933).

Machines for shaping electric lamp bulbs. LAMP PATENTS, LTD. (W. R. Freeman). Brit. 441,646, Feb. 5, 1936 (Oct. 24, 1934).

Making glass wool or threads. O. OSWALD & Co. Ger. 617,021, July 18, 1935 (Nov. 25, 1930), 32*a*, O 228.30; *Jour. Soc. Glass Tech.*, **19** [76] A401 (1935).—An electri-

cally heated furnace is built as a shaft and provided with a funnel-shaped zone to locate the region of intense heat some distance below the top where the raw material is charged in.

Manufacture of molded heat-resisting glassware. E. J. Jobling Purser. Brit. 442,882, March 4, 1936 (Aug. 17, 1934).

Means for feeding molten glass to glass-forming machines. United Glass Bottle Manufacturers, Ltd., and T. C. Moorshead. Brit. 442,303, Feb. 19, 1936 (Sept. 28, 1934).

Means for supporting glass or other sheets while undergoing tempering or heat treatment. S. Dunlop (American Securit Co.). Brit. 442,633, Feb. 26, 1936 (March 27, 1935).

Measuring glasses, etc., particularly for the administration of medicine or liquid foods. A. C. Coulter. Brit. 442,575, Feb. 26, 1936 (April 23, 1935).

Method and apparatus for drawing glass sheets. Simplex Engineering Co. Brit. 442,178, Feb. 19, 1936 (May 16, 1934).

Method and apparatus for forming hollow glass articles. G. E. Howard (Hartford-Empire Co.). U. S. 2,033,076, March 3, 1936 (June 1, 1934).

Method of feeding molten glass. T. F. Pearson. Brit. 441,682, Feb. 5, 1936 (April 23, 1935).

Method of making a double glazed unit. R. L. Clause (Pittsburgh Plate Glass Co.). U. S. 2,032,003, Feb. 25, 1936 (Nov. 3, 1934).

Method of purifying glass sand. R. R. McGregor and E. W. Tillotson (Macbeth-Evans Glass Co.). U. S. 2,031,969, Feb. 25, 1936 (Aug. 30, 1934).

Method of sealing charged glass bulbs. A. J. Loepsinger (General Fire Extinguisher Co.). U. S. 2,031,660, Feb. 25, 1936 (Nov. 26, 1932).

Multi-ply glass sheet glazing unit. C. D. Haven (Thermopane Co.). U. S. 2,030,869, Feb. 18, 1936 (Oct. 12, 1934).

Ophthalmic lens. E. D. Tillyer and H. R. Moulton (American Optical Co.). U. S. 2,033,101, March 3, 1936 (Oct. 13, 1933).

Pot furnace comprising a series of single-pot cells fired individually by means of tangential burners. "Wirbelstrahlbrenner" Openbau-Ges. Ger. 599,486, Sept. 24, 1930, Kl. 32a, 2/01; *Keram. Rundschau*, **43** [6] 68 (1935). R.W.D.

Process and apparatus for making plate glass. A. H. Stevens (Pittsburgh Plate Glass Co.). Brit. 442,702, Feb. 26, 1936 (March 23, 1935).

Process and device for tempering glass. Assurex le Roi des Verres de Securité Magnien, Monnier, & Cie. Brit. 442,693, Feb. 26, 1936 (Jan. 16, 1934).

Process for manufacturing glass tubing and glass rods with colored glass insets. Firma Jos. Riedel. Ger. 598,898, April 26, 1933, Kl. 32a, 24/02; *Keram. Rundschau*, **43** [4] 45 (1935). R.W.D.

Production of insulating materials made out of spun glass. Carl Alfeis. Ger. 556,702, Sept. 8, 1931, Kl. 806, 9/03; addition to Ger. 531,861; *Keram. Rundschau*, **43** [4] 44 (1935). R.W.D.

Regulating motion of sheet glass through the leer. Glaceries de la Sambre Soc. Anon. Ger. 617,416, Aug. 1, 1935 (Dec. 24, 1931), VI/32*a*, Gp. 29; *Jour. Soc. Glass Tech.*, **19** [76] A396 (1935).—Means are provided, in a sheet glass leer having several sections of feed rollers electrically driven, for controlling the feeding of the sheets forward by means of a switch operated by the sheets as they arrive at the cutting table.

Safety glass. J. W. Kamerer and L. S. Whitmire (Duplate Corp.). U. S. 2,030,878, Feb. 18, 1936 (Oct. 21, 1933).

Sealing vitreous envelopes. General Electric Co., Ltd. (Patent-Treuhand-Ges. für elektrische Glühlampen). Brit. 441,559, Feb. 5, 1936 (July 27, 1934).

Shearing mechanism. W. C. Weber (Corning Glass Works). U. S. 2,032,075, Feb. 25, 1936 (April 28, 1933).

Single-arm automatic suction bottle machine. Etienne Féchoz. Ger. 598,831, Feb. 9, 1932, Kl. 32a, 13; *Keram. Rundschau*, **43** [4] 44 (1935). R.W.D.

Structural Clay Products

Chemical data on autoclave silicate (lime-sand) materials. M. I. Khigerovitch and D. S. Novakhovskaya. *Stroitel. Material.*, No. 9, pp. 25–29 (1935). P.B. & E.S.

Determination of Young's modulus for building materials by a vibration method. G. Grime. *Phil. Mag.*, **20**, 304–10 (Aug., 1935).—Many building materials, because of their shape, are not easily adapted to the determination of Young's modulus by the usual extensometer method, but are suitable for the determination of the natural frequency of longitudinal vibration. Such a vibration is excited in a specimen by tapping one end and is recorded photographically with the aid of a cathode-ray oscillograph; its frequency is determined by comparison with a superimposed time scale. Young's modulus for the specimen may then be calculated from the equation, $E = 4l^2 n^2 \rho/[1 - \pi^2\sigma^2K^2/2l^2]$, where E is Young's modulus, l the length of the specimen, n the frequency of longitudinal vibration, ρ the density of the specimen, σ Poisson's ratio, and K the radius of gyration of cross-section about the line of centers of the normal sections. The size and shape of the specimens may be chosen so that the bracketed term differs from unity by a negligible amount and the following approximation is sufficiently accurate: $E = 4l^2n^2\rho$. The maximum possible error for this method is 2.1%. Results agree with the extensometer method within about 1.0%. By this method Young's modulus may be determined for irregular-shaped building materials, such as stone prisms of triangular cross-section, roofing tile, lime mortars of low strength, etc. A large number of small specimens may be treated rapidly, and it affords a convenient means of observing the progressive changes in Young's modulus due to heat treatment, weathering, etc. P.T.C.

Early brick making in Australia. Alfred Dawes. *Clay Prod. Jour. Australia*, **2** [Oct.] 13–15; **3** [Nov.] 12–15; [Dec.] 22–23 (1935); **3** [Jan.] 24–25 (1936).—A

historical account of the evolution of the industry is given by a man whose family has been connected with it for five generations. H.H.S.

Extra-light brick. ANON. *Corriere Ceram.*, **16** [12] 495–97 (1935).—Directions for obtaining and improving extra-light brick are given. M.V.C.

Facing brick out of Chicago commons. ANON. *Brick Clay Rec.*, **88** [2] 55–56 (1936).—As the result of three years of intensive research, the Illinois Brick Co. is now able to transform Chicago common brick into facing brick. Basic inorganic materials, fused into the clay body of the brick at a kiln temperature of over 1900°F, make this new dress on the commons of durable color. The brick are sold under the trade name of Autumtints, the name of the machine used in the process wherein several materials are impregnated into the surface of the clay column. Illustrated. E.J.V.

Stoneware's winning battle. A. W. JONES. *Clay Prod. Jour. Australia*, **3** [Jan.] 27 (1936).—A large sewerage scheme around Adelaide (S.A.) has been decided in favor of stoneware pipe as against pitch-lined concrete. H.H.S.

PATENTS

Apparatus for making brick, etc., of toy or full size. R. ADRIAANSZ AND E. SPEAKMASTER. Brit. 442,543, Feb. 26, 1936 (Aug. 10, 1934).

Building construction systems and blocks, brick, tile, etc., used therein. J. BUTTERWORTH AND R. T. PEARSON. Brit. 442,286, Feb. 19, 1936 (July 25, 1934).

Process of manufacturing building materials. HERMANN HARKORT. Ger. 598,611, Jan. 1, 1932, Kl. 80a, 46; *Keram. Rundschau*, **43** [6] 68 (1935).—Hollow bodies are made in two pieces and assembled during the drying process, strips of the same material being interposed between the two sections; the bodies are split again after firing. R.W.D.

Refractories

Accelerated firing of silica brick. G. V. KUKOLEV, I. I. SLEPCHENKO, V. D. TZIGLER, AND A. T. ZELENSKAYA. *Ogneuporui*, **3** [8] 555–66 (1935). P.B. & E.S.

Application of physicochemical principles to the manufacture of extrasiliceous refractory products: II. M. LÉPINGLE. *Ind. chim. Belge*, **7** [2] 43–55 (1936).—Silica brick (Dinas) are high-grade acidic materials, 95% SiO_2 at the least. The main characteristics of siliceous refractories are a high melting point and a great cohesion at high temperature. Properties of the different varieties of SiO_2 and their allotropic states are surveyed. The Day and Shepherd equilibrium diagram, corrected by Endell and Rieke, should still be slightly altered. Important modifications in physical and crystallographic constants occur when SiO_2 undergoes transition. The expansion curve of quartz plotted by Travers and Goloubinoff is in agreement with that given by Le Chatelier; the magnitude of the expansion taking place at 575°C is smaller (0.27), however, than that observed by Le Chatelier (0.42). Above 440°C tridymite expands very little, but its coefficient of expansion is in no case negative, as in the Le Chatelier diagram. The transformation of a given variety of SiO_2 into another variety is slow, but it can be accelerated by the presence of catalysts, preferably by crystals of the same nature as that of the desired variety. This property is in agreement with the Tammann theory. The first silica brick were manufactured in 1822 in England by Young. Originally, silica brick were cut off quartzite rocks and afterward fired. Now the raw materials are ground, graded, batched, mixed with limewater, dried, and fired. Shapes are fired up to 1500°C for a fortnight. Conditions of the manufacturing process are fully described. Silica brick contain 10 to 30% quartz, 25 to 30% tridymite, 35 to 70% cristobalite, and about 10% amorphous silica or glass. For Part I see *Ceram. Abs.*, **15** [2] 63 (1936); see also *ibid.*, [4] 125. R.W.D.

Application of the Ritex process to the manufacture of chrome brick. H. P. HEUER. *Steel*, **97**, 22–25, 30 (Aug. 19, 1935); abstracted in *Jour. Iron Steel Inst.*, **132** [2] 327 (1935).—Ritex chrome brick are compared with ordinary chrome brick in respect to chemical analyses, density, refractoriness, crushing strength, and volume stability. It is shown that Ritex chrome brick is superior to ordinary fired chrome brick; it is also more resistant to spalling and has a lower heat conductivity. Ritex contains about 32% of magnesite, compared with about half this amount in ordinary chrome brick; tests revealed that the magnesite present was to some extent responsible for the improved physical characteristics. During manufacture, Ritex brick undergoes sizing and bonding processes, but no kiln firing. As a substitute for fired chrome brick, or, in certain situations, for silica and magnesite brick, Ritex is claimed to be entirely successful.

Ceramic refractories. J. H. PARTRIDGE. Read before Junior Inst. Engrs.; abstracted in *Electrician*, **116** [4] 95 (1936).—A general statement of refractory materials and methods of manufacturing is given. Articles which must possess a high electrical resistance are made of pure alumina and magnesia by the recrystallization method and fired to a temperature above the recrystallization point. H.K.R.

Clay gun stops iron notch under full blast pressure. ANON. *Steel*, **95**, 39–40 (Dec. 24, 1934); abstracted in *Jour. Iron Steel Inst.*, **131** [1] 351 (1935).—An outline is given of the various improvements effected in the design and construction of the Brosius clay gun. To meet the modern trend of electrifying all equipment, the two-motor automatic gun was developed in 1933. This gun has a single clay barrel with a capacity of 9 cu. ft. A distinctive feature is the elimination of the clamping mechanism. The gun is pulled into the hole and held in position by a rope attached to the furnace front and wound on a worm gear operated by a 10 h.p. motor, mounted inside the boom; the splasher plate is automatically raised as the gun swings in. The iron notch is stopped completely, under full blast pressure, in 8 to 12 seconds, depending on the amount of clay required. The entire equipment is controlled from any convenient point in the casting house. The gun proper is driven either by a straight mechanical gear drive or by a self-contained motor-driven hydraulic oil gear unit, this unit and its driving gear being mounted on the gun.

Clays, their utilization in the glass industry, origin, composition, and mining. J. Le Braz. *Glaces & Verres*, **8** [45] 2–8 (1935).—The operations of melting and refining glass take place in tank or pot furnaces built with refractory materials which must stand the high temperature required for plaining the metal and resist efficiently the corrosive and erosive action of molten glass. Some varieties of aluminous clays, although characterized by high resistance to chemical reagents, are not suitable for building the crown of glass furnaces. Raw materials used for manufacturing tank blocks are sillimanite ($SiO_2 \cdot Al_2O_3$), a natural product abundant in India, mixed with pure bond clay, mullite ($2SiO_2 \cdot 3Al_2O_3$), or a similar artificial product. These materials have great mechanical resistance, even at 1600°C, and their fusing point is close to 1850°C. Pots are made with pure pot clay mixed with grog and pot shell. The degree of resistance of clay depends on the proportion of kaolinite ($2SiO_2 \cdot Al_2O_3 \cdot 2H_2O$) it contains. Pure kaolinite undergoes a deep transformation at about 900°C and softens near 1800°C, but the latter temperature may be considerably lowered by the presence of impurities. Origin of clay is the alteration of feldspars; primary clay is found where it has originated, while secondary clay has been carried away from the mother rock by sedimentation. Chemical compositions of French pot clays are given. That of Provins is valued for its plasticity, regularity of composition, and high refractoriness. Lumps of raw clay are graded in several qualities depending on their degree of purity. Most French clay deposits are found at an appreciable depth below ground level and, consequently, are preferably exploited by shaft-mining processes which L. describes. French production of all kinds of clays amounts to 10 million tons yearly, including about 350,000 tons of refractory clays. R.W.D.

Corrosion effects on refractories of enamel furnaces. Anon. *Keram. Rundschau*, **42** [48] 597–98 (1934).—Practical experiences were made on enamel muffle furnaces, the temperature inside the muffles being kept constant at 950°C. Corrosion is due to temperature and particularly to dusty ash carried by flame. Gas producers with dust pockets generally give better results than producers built directly in the furnace. Corrosion is important in burners, at partition walls below the muffle, and at muffle-bottom plates. Silica material has short life. Aluminous refractory (38% Al_2O_3) is not satisfactory, but is decidedly better. A mix of 90% sillimanite and 10% mullite lasts 14 months instead of 3. There is some sintering in the hottest parts, and compact crystallization without shrinkage or sensibility to change of temperature. Silicon carbide intended for muffles should be mixed with the smallest possible quantity of bond clay (10%). Quartz and alkali must be avoided to prevent expansion and corrosion. For the bottom and parts exposed to heat and ashes, mullite is the best material. Such a muffle, in operation for one year, is satisfactory; the saving of fuel due to higher heat conductivity is 20 to 25%. Illustrated. F.E.V.

Determination of mullite in refractories. B. B. Kraft and T. A. Gurvich. *Ogneuporui*, **3** [9] 675–80 (1935). P.B. & E.S.

Developments in the design and operation of open-hearth furnaces. R. S. Bower. *Iron & Steel Engr.*, **12** [7] 413–24 (1935).—B. traces the development of the open-hearth furnace from the first commercial installation at the Sireuil works of Piere and Emil Martin in 1864 to the modern plants, which tap as high as 220 tons into one ladle. Producer gas, coke gas and tar, and combinations of fuels are used for open-hearth furnaces. Meters and valves used in operating the furnaces are discussed. Insulation has been applied to reduce heat loss during the past eight years. Insulating brick is used in new construction, while for old construction slag wool or expanded vermiculite mixed with plastic fire clay is used. This is plastered on the outside walls of the furnace in layers 1 in. thick until 3 or 4 in. have been applied and then the roofs are covered with expanded vermiculite or slag wool. Different types of furnace controls are described. Illustrated. E.J.V.

Digester lining developments. A. F. Richter. *Paper Trade Jour.*, **96** [6] 35 (1933).—Developments and trends in the design and construction of sulfite digester linings are reviewed. Durable acidproof brick have been perfected which are also satisfactory in resisting spalling or splitting caused by precipitation of mineral salts in the pores of the brick. Carbon linings are inert but have high thermal conductivity and low linear expansion. C.B.J.

External heat loss of blast furnaces. D. F. Marshall. *Engineering*, **139** [3617] 503–505 (1935).—The heat losses of four blast furnaces are determined and illustrated. In all cases the heat carried away in the cooling water amounted to over 82% of the total loss. The total external heat loss is not markedly influenced by differences in furnace operation, except where such changes create a necessity for additional water-cooling. The heat loss from the shaft of each furnace constitutes a relatively small proportion of the total loss. H.E.S.

Foreign raw materials in German electric furnaces. W. Fischer. *Elektrowärme*, **6** [1] 13–17 (1936).—Metals and refractories which must be imported into Germany for the construction of electric furnaces are discussed. Ni (about 50 tons yearly), Cr, and asbestos are among the most important. The replacement by domestic materials is investigated. M.H.

History of the American crucible business. Jonathan Bartley. *Metal Ind.*, **34** [2] 47–53 (1936).—A history of the companies manufacturing graphite crucibles from 1827 to date, written by one of the pioneers, is given. H.K.R.

Improving open-hearth furnace design. W. C. Buell, Jr. *Steel*, **96** (June 17) 49–52; (June 24) 50–54; **97** (July 1) 40–46; (July 8) 50–53; (July 15) 57–61; (July 22) 45–48 (1935).—Slag pockets are discussed and data for the calculation of the slag-pocket size are given. The effect of improvements in design is indicated. Refractories used in slag-pocket construction and methods of effecting economies in this direction are dealt with. Design of the slag pockets, particularly the construction of the arches to the pockets, is considered. The detailed design of the steelwork for the slag pockets is treated, as well as special constructions which have been tried and found wanting. The layout and constructional details of typical fantails used to connect the slag pockets and regenerator chambers are described, and the various factors which influence design are examined. *Ibid.*, **97** (July 29) 40–45; (Aug. 5) 58–62; (Aug. 12) 54–56 (1935); abstracted in *Jour. Iron Steel Inst.*, **132** [2] 377 (1935).—The dimensions

of typical regenerator chambers (exclusive of the checkerwork contained therein) are given. Regenerator walls and roofs are discussed, and data relating to various types of construction are presented. The various details of construction are examined, and the superiority of insulated over uninsulated chambers is demonstrated.

Influence of gaseous hydrocarbons on refractories. M. P. Babkin and R. N. Golovatuiĭ. *Ogneuporui*, **3** [8] 582–87 (1935).—The deposition of carbon on the inner side of the refractory lining of coke ovens depends on the chemical composition of the refractories. At low temperatures (600°) the increase of silica content decreases the rate of deposition of carbon; at 800° and above, much larger deposits are formed on silica brick than on grog brick. The carbon is in a more amorphous condition. The addition of 1 to 2% iron oxide increases carbon deposition in all cases. On grog and semiacid grog it attains the highest rate at 800° and decreases afterward, and its form becomes graphitic. The increase of the firing temperature of refractories lowers the deposition; the increase of porosity increases it in proportion. The deposition permeates equally the whole thickness of the brick. P.B. & E.S.

Insulating refractory for heating furnaces. Anon. *Iron Age*, **131** [11] 433, ad. p. 10 (1933).—A B. & W. No. 80 insulating fire brick is about one-fourth as heavy as standard fireclay brick, has a fusion point of 3190°F, withstands temperatures up to 2850° without shrinkage or other damage, and has excellent load-carrying properties.
E.H.McC.

Kazakstan andalusites and dumortierites. K. N. Ozerov. *Ogneuporui*, **3** [8] 628–34 (1935). P.B. & E.S.

Latest refractories for glassmelting furnaces. B. A. Nikolskiĭ. *Keram. i Steklo*, **11** [10] 20–23 (1935).—A detailed description is given of the production and properties of Corhart brick manufactured by the St. Gobain Co. in France. M.V.C.

Lining of high-frequency furnaces. Anon. *Montan. Rundschau*, **27** [2] 1–3 (1935).—Details are given of English practice for lining high-frequency furnaces. Two types of linings are used, suitable for acid as well as basic lining; both have about the same length of life. (1) Rohn lining: the dry, powdered material of definite screen analysis is tamped between a cylindrical steel plate and the induction coil, which is covered with asbestos sheets. During the smelting of the first charge this tamped material is sintered to a small depth, while the outer part of the lining remains porous and offers some heat insulation. (2) Lining with fired brick: ring-shaped brick, dove-tailed into each other, are pressed together carefully. For basic linings, fired Austrian or Greek magnesite is used; for acid linings, silica brick. B.H.S.

Magnesite in the British Empire. A. Comber. *Mining Mag.*, **50** [1] 24–27 (1934); abstracted in *Referat. Silikatliteratur*, No. 373 (1935).—The modifications of magnesite are discussed and its deposits in the British Empire are described. M.V.C.

Mechanical ramming of grog refractories. V. A. Ruibnikov. *Ogneuporui*, **3** [9] 671–75 (1935).—Different kinds of ramming equipment are described. P.B. & E.S.

Methods of investigating the quality of magnesite brick. S. I. Kilesso. *Ogneuporui*, **3** [8] 597–605 (1935).—Analysis of Russian and foreign literature shows that characteristics of magnesite brick are determined by a compressive test, specific gravity, volume weight, and temperature of beginning and end of shrinkage under a load of 2 kg./cm.^{2}
P.B. & E.S.

Olivine (dunite) refractories. M. A. Uralov and A. S. Berezhnoĭ. *Ogneuporui*, **3** [8] 587–94 (1935).—Dunite, a waste rock of the gold industry, consists principally of olivine and serpentine with small amounts of magnesite and chromite and possesses a high refractoriness and resistance to the influence of open-hearth slag. The production process is described. The brick had the following characteristics: setting, 0.5 to 4.5% (depending upon the composition of the charge); volume weight, 2.45; apparent porosity, 25 to 28%; mechanical strength, 160 to 340 kg./cm.^{2}; refractoriness, cones 37 to 38; beginning of softening under load, 2 kg./cm.^{2} at 1620° to 1660°, collapse at 1720° to 1770°. Their resistance to spalling and to slags was higher than that of silica brick. P.B. & E.S.

Petrographic investigation of zone formation in silica refractories in a glassmelting furnace. N. G. Kaznakova. *Ogneuporui*, **3** [9] 667–71 (1935).—Silica brick in glassmelting furnaces undergo several physical and chemical changes in service, leading to the formation of five distinct zones, the colors varying from white on the inner side of the walls to red on the outer side; no cristobalite zone is perceivable. Comparison with silica brick used in an open-hearth furnace shows that service conditions of silica brick for glassmelting furnaces are less rigorous. P.B. & E.S.

Physical aspects of refractory insulation. John D. Sullivan. *Brick Clay Rec.*, **88** [2] 74–76 (1936).—Use of insulation may be limited not only by the effect of temperature on the insulation itself but also on the refractory wall. Insulation has no effect on the temperature inside the furnace or on the inner wall of the refractory lining. The temperature of the refractory mass is increased. If the inner face of the refractory is operating near the upper permissible temperature limit, application of insulation may bring the hot layer back far enough to cause dripping or plastic flow. The temperature at the interface of the dense brick and the insulating covering is the hottest of any point in the latter. Lightweight refractories have, as disadvantages, poor mechanical strength, poor resistance to spalling by temperature changes, and high shrinkage in service. Lower thermal capacity, the outstanding feature of lightweight brick, offsets costs. Data on temperatures of the roof on an open-hearth furnace, insulated, are given.
E.J.V.

Production and service of stoppers and nozzles. A. M. Trakhtenberg and I. A. Tatasrkiĭ. *Ogneuporui*, **3** [9] 648–54 (1935).—An investigation undertaken at an iron and steel plant demonstrated that nozzles must be produced with magnesite inserts for casting boiling metal and without them for metal in a calm state. The latter nozzles should be fired at over 1400° and must have a maximum porosity of 23% and an alumina content of 34%. Nozzles with inserts can be produced from a batch containing not less than 31 to 32%. A high alumina content is no substitute for the magnesite inserts as protection against erosion by the boiling metal. The porosity can attain 28%, and the firing is satisfactory at 1300°. Stoppers must be fired at about 1350° and possess a maximum porosity of 25%.

Connecting the stopper with the shank with the aid of a bolt turning through 90° is recommended. P.B. & E.S.

Production of silicate brick. A. V. Volzhenskiĭ. *Stroitel. Material.*, No. 9, pp. 17–25 (1935).—The most appropriate schedule of temperature changes in the vapor-treating autoclave and some factors influencing the strength of the brick are discussed. P.B. & E.S.

Progress in the technic of heat protection at high temperatures. M. Frühauf. *Wärme- & Kälte-Tech.*, **37** [4–5] 1–3; [6–7] 1–4 (1935); abstracted in *Chem. Zentr.*, ii, 3563 (1935).—A review is given of (1) requirements for insulating materials for high temperatures, (2) the insulating value of air in porous products, and (3) suitable filling materials for insulating products. M.V.C.

Rationalization of hand molding of coke-oven silica brick. G. B. Taubin. *Ogneuporui*, **3** [7] 499–505 (1935).—At the Krasnogorovka plant, shaped silica brick for coke ovens were formerly molded in large, heavy, iron molds with the aid of long-handled heavy wood hammers. Ware with long cracks and with an irregular surface were obtained. Use of collapsible wood molds produced green brick of better quality and gave increased production. P.B. & E.S.

Recent developments in refractories. C. E. Moore. *Iron & Coal Trades Rev.*, **132** [3538] 4 (1936).—Improvement of existing refractories and the creation of new refractory materials in recent years are discussed. Accuracy of size and shape has been considerably improved without increase of cost. The alumina content of fire brick is now higher than formerly, and sillimanites are used extensively. Smaller sizes have been found advantageous and more economical. Silicon carbide and Siloxicon are widely used in muffles, furnace tubes, and refractory supports. Clay-bonded silicon carbide is now generally reserved for use as kiln tile, furnace bottoms, and crucibles where neither the greatest refractoriness nor the highest thermal conductivity are required. Severe conditions are met by crystallized silicon carbide which possesses both high thermal conductivity and great strength. Zirconium silicates are applied where the high price permits, as in laboratory and special furnace work; although this material is nonspalling and has high refractoriness and strength, its slag resistance, especially to metallic oxides, is poor. M.H.

Refractories for cupola furnaces. A. V. Tereshchenko and O. M. Margulis. *Ogneuporui*, **3** [8] 566–73 (1935).—The most appropriate refractory for the zone of fusion is semiacid quartz-grog brick made from 40% sand or quartz residue from the washing of kaolin, 20% grog from binding clay, and 40% refractory clay fired at cone 13 (1380°C). The run of the furnace improves on account of the decreased amount of slag formed. Silica brick are unfit for cupola furnaces. The usual grog brick can be used, but with less success; the increase of alumina content in the latter does not influence its endurance positively. Mortar for semiacid brick must be made of 70% clean sand and 30% plastic refractory clay. P.B. & E.S.

Refractories for electric furnaces. M. Gagnaire. *Sci. et Ind.* (*Electricité*), **19** [4] 149 (1935).—Electric furnaces involve the use of a wide variety of refractory products because they attain the greatest temperature range among industrial furnaces. General properties of refractories are first reviewed, *i.e.*, (1) chemical composition, (2) heat resistance or refractoriness, (3) true and apparent density or specific gravity, (4) porosity, (5) permeability, (6) crushing temperature under a given load and crushing strength at room temperature, (7) thermal expansion and permanent growth after heating, (8) corrosion and wear resistance, (9) resistance to thermal shock, and (10) thermal and electric conductivities. The refractory products which are reviewed are (*a*) silica, (*b*) magnesite, (*c*) silica-alumina, (*d*) miscellaneous products, *i.e.*, sillimanite, silicon carbide, graphite, zircon, corundum, dolomite, and lime, (*e*) products with special structure (hollow shapes are obtained with cork forms), (*f*) products with high electrical insulation and very close grains, (*g*) mortars, cements, and coatings, and (*h*) heat-insulating products. A concise account is given of each type of product available to the electric-furnace designer. Despite the wide variety of products, cases are numerous when an adequate product fails for a special application. Much research work remains to be done. F.R.

Refractories and insulation. J. L. Spence and J. W. Craig. *Can. Chem. Met.*, **20** [2] 50 (1936).—The practical problems of furnace refractories, covering a wide variety of equipment, types of refractory cements, monolithic and castable refractories, and the various types and methods of application of insulation are taken up in detail. E.J.V.

Refractory linings for the protection of grog brick against corrosion in glass tank furnaces. L. M. Blumen. *Keram. i Steklo*, **11** [9] 9–16 (1935).—The destruction of refractories by melted glass is of a physical and chemical character. A physicomechanical process occurs first; melted glass penetrates into the pores and promotes the occurrence of pyrochemical reactions. The refractory lining should possess the following properties: (1) sufficient refractoriness, (2) chemical resistance, and (3) coefficients of expansion and shrinkage identical with those of grog brick. Fluxes are used to produce a more dense body, but they lower refractoriness and therefore should be used sparingly. They act as a bond between the grog brick and the lining and have the effect of mineralizers, promoting the formation of mullite crystals from the grog. Waterglass answers these requirements: it makes the structure dense, and the Na_2O present promotes the formation of mullite. The protective effect of the lining is based on the fact that while the lining is being destroyed, the basic grog brick is subjected to a process of mullitization which is greater in the contact-metamorphic zone. Experiments with such linings and results obtained are discussed in detail. M.V.C.

Refractory materials in the electric industry: history, metallurgy, and applications. P. Fustier. *Rev. ind. Minérale*, pp. 325–42 (1935); abstracted in *Chem. Zentr.*, **i**, 825 (1936).—The development and use of pure W and Mo metals are reviewed. M.V.C.

Refractory materials for the iron and steel industries. Alfred B. Searle. *Iron & Steel Ind.*, **8** [5] 158–60 (1935).—S. reviews recent progress in invention, research, and application of refractories. He regrets the lack of a ceramic term corresponding to "alloys" in metallurgy and hopes that eventually refractories may be refined and standardized as completely as metals. He cites the claim of Russian metallurgists that black Dinas brick are much superior to ordinary silica brick and calls attention to the

difficulty of preparing specifications for refractory materials. In place of specifications S. suggests that a friendly coöperation between the producer and user will give far better results with much less worry and disappointment. S. touches briefly on basic refractories, insulation, and foundry sands. 14 references. E.H.McC.

Service of silica brick in open-hearth furnaces of the Petrovskiĭ plant (at Dniepropetrovsk). V. TRUBENKOV. *Ogneuporui*, **3** [7] 492–98 (1935).—The longer life of silica brick in the roofs of open-hearth furnaces in 1934 as compared with 1933 was due principally to improvements in running the furnace. The repairs undertaken in this furnace and the physical and chemical changes in silica brick from its roof are described. P.B. & E.S.

Siemensite. YA. V. KLYUCHAROV. *Ogneuporui*, **3** [8] 594–96 (1935).—Investigation of four samples of cast and pressed Siemensite disclosed a higher content of metallic iron in the latter; the mineralogical composition was the same for both (spinel 83.6, opaque mineral 11.1, glass 2.3, pores 3.0%); the specific weight differed (3.98 for cast Siemensite, 3.76 for the pressed sample); the porosity of the former was much lower (1.17 against 15.65 to 15.73); the temperature of the beginning of shrinkage under load of pressed Siemensite (1540°) was lower than data found in the literature concerning the cast variety (1800°). The resistance to spalling was not high (6 coolings). P.B. & E.S.

Silica brick of the Beloretzkiĭ works in the arches of open-hearth furnaces. A. T. ZHAK. *Ogneuporui*, **3** [9] 642–47 (1935). P.B. & E.S.

Suspended, unfired reinforced roofs for open-hearth and electrical furnaces. I. S. KAINARSKIĬ, B. YA. PINES, AND S. YA. KOZLOV. *Ogneuporui*, **3** [9] 661–66 (1935).—The use of metal-cased, magnesite-chromite blocks gave good results. P.B. & E.S.

Testing and evaluation of heat-insulation materials. W. SCHAIRER. *Gas- & Wasserfach*, **78** [50] 939–43 (1935).—The measurement of heat insulation by the apparatus of Schmidt and Hencky is described. It consists in putting a layer of heat insulation of known property on the heat insulation to be measured. The heat absorption by the latter determines the heat conductivity of the former. By proper arrangement of the heat insulation of known quality, the whole measurement is reduced to one of temperature measurement. The method is explained by the determination of the heat-protective values of refractory powders, spun glass, and metal foils. Taking into account price and cost of putting the insulation in place, masses of kieselguhr in general are the most economical. In practical cases, a heat loss of 140 k.cal./m².hr. can be admitted without having to resort to too thick layers of heat insulation on high-pressure steam lines. M.H.

Thermal insulation of Siemens-Martin and electric furnaces. S. WOHLFAHRT AND O. ELL. *Jernkontorets Ann.*, **118**, 447–74 (1934); *Stahl & Eisen*, **55** [22] 590–91 (1935); abstracted in *Referat. Silikatliteratur*, No. 1913 (1935).—The advantages of insulating furnaces are discussed, and data on lowering heat losses due to radiation and conduction are given. M.V.C.

BOOK

Manufacture of Refractories from Indian Magnesite. H. K. MITRA. *Proc. Twenty-First Indian Sci. Congress (As. Soc. Bengal)*, 353 pp. (1934); *Quart. Jour. Geol. Mining Met. Soc. India*, **6** [1] 19–25 (1934); *Tisco Rev.*, **2** [6] 346–50 (1934).—M. describes the process of manufacture of pea-sized, dead-burned magnesite and magnesite brick followed in the works of the Tata Iron & Steel Co., Ltd., Jamshedpur, India, from raw Indian magnesite which, like the Washington magnesite, is pure and amorphous or cryptocrystalline. The magnesite is crushed in a gyratory crusher, ground and mixed with mill-scale, about 2% of the weight of the raw magnesite (the addition of iron ore introduces many undesirable impurities), mixed with water in a pug mill, molded in a dry-press brick machine, and dried in a tunnel drier. The dried brick are fired in a shallow stationary kiln using coke-oven gas. The usual temperature of dead-burning is 1600°C, and the material is given a good soaking at this temperature. A fully dead-burned material has also been obtained at as low a temperature as 1450°C, but the period of soaking in that case was very prolonged. The crumbled and completely shrunk brick is next crushed and screened to produce pea-sized, dead-burned magnesite, or it is finely powdered for making brick. Photomicrographs show the development of periclase in the Jamshedpur product as more pronounced than in the Austrian dead-burned magnesite, and the true density of the former is higher than that of the Austrian product. The analyses are as follows:

	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Loss	True density
Jamshedpur dead-burned magnesite	2.44	5.86	0.94	1.70	89.80	0.06	3.70
Austrian dead-burned magnesite	2.32	6.57	4.23	2.20	84.25	0.60	3.65

For every ton of the raw material received at the Works only half a ton of dead-burned product is obtained, the remainder being lost as carbon dioxide gas. A.P.S.

PATENTS

Construction of water-cooled furnace walls. B. H. SCHIELDROP. Brit. 441,649, Feb. 5, 1936 (Nov. 3, 1934).

Heat-insulating composition and method of making. A. B. CUMMINS (Johns-Manville Corp.). U. S. 2,033,106, March 3, 1936 (July 27, 1932; Jan. 16, 1936). A method of manufacturing a heat-insulating composition adapted for use at elevated temperatures comprises forming a slurry of a mixture of diatomaceous silica calcined in finely divided condition at a temperature of at least 1600°F, a comminuted inert material characterized by low density, and water, and forcing the slurry under pressure into a filtering mold, whereby water is removed and a block is formed.

Manufacturing high-grade refractory blocks. C. OTTO & Co. Ger. 599,679, July 7, 1934, Kl. 80b, 8/18; addition to 589,959; *Keram. Rundschau*, **43** [6] 68 (1935). The ground-mass (50% of the bulk weight) is represented by powdered aluminous or siliceous materials (corundum, quartz) of particle size less than 0.1 mm. in diameter. The nature of additional grog depends on the kind of block considered. R.W.D.

Process for manufacturing refractory products from raw materials rich in magnesium orthosilicate, particularly olivine rocks. V. M. GOLDSCHMIDT. Brit. 441,516, Feb. 5, 1936 (July 13, 1934).

Process of manufacturing spinel-like products and their subsequent use for the production of refractory materials. T. R. HAGLUND. Ger. 600,170, April 12, 1933, Kl. 80b, 8/09; *Keram. Rundschau*, **43** [6] 68 (1935). R.W.D.

Refractory. W. M. FARNSWORTH (Republic Steel Corp.). U. S. 2,033,886, March 10, 1936 (Oct. 3, 1933). A refractory consists of about 2 parts by weight of olivine, about 1 part by weight of chrome ore, and about 3 parts by weight of calcined magnesite.

Terra Cotta

Acoustics of buildings. R. E. W. H. HAIG. *Indian Eng.*, **90** [16] 345; [17] 363; [18] 384; [19] 404; [20] 424 (1931).—The characteristics of sound, the behavior of sound in an enclosed space, echoes, resonance, interference, loudness, reverberation, absorption of sound by different materials, and preferred reverberation period are discussed. H. opines that if Knudsen's graph and Eyring's formula are used, results achieved will be as near perfection as present-day knowledge permits. Correction of faulty acoustics is discussed, examples being quoted from Acoustics of Buildings by Watson (1930). The design of an auditorium is considered, and various sound absorbents are briefly described, with names and addresses of firms from whom the materials can be obtained and the approximate prices. The uselessness of stretched wires to cure defective acoustics and sound quieting by adding absorption are treated. A.P.S.

Discoloration and efflorescence of tile. E. MOTSCHMANN. *Keram. Rundschau*, **41** [27] 352–53 (1933).—A mix of $BaCl_2$ and $BaCO_3$ is the best reagent to expel soluble sulfates and prevent efflorescence. In the filter-pressing process or in the absence of raw material control, $BaCl_2$ is not recommended because an excess gives efflorescence. The advantages of this mixture under normal circumstances are as follows: (1) the activity of $BaCl_2$ is nearly four times as great as that of $BaCO_3$; (2) action is certain, $BaCl_2$ being very soluble; (3) action is constant, whereas the efficiency of carbonate alone is subject to conditions (quality, way of mixing); (4) the addition of $BaCl_2$ should be computed to expel only a part of the soluble salts. Transitory formation of new soluble chlorides, *e.g.*, KCl in presence of gypsum, has no importance because these salts are decomposed during firing. The mixture is 25% cheaper than carbonate alone. See also *Ceram. Abs.*, **12** [12] 426 (1933). F.E.V.

Engobes. ERNST KEMPE. *Sprechsaal*, **68** [48] 703–704 (1935).—K. reviews various types of engobe mixes and their application, with special regard to lustrous and weather-stable engobes. M.V.C.

Engobes in the ceramic industry. FRIED.-BIGOT. *Rev. mat. constr. trav. pub.*, No. 314, pp. 165–68B; No. 315, pp. 179–81B (1935).—Complete details of the manufacture of engobes are given, and it is shown that coating with an engobe is in no sense a covering up or disguise for the buyer, but in reality a treatment which gives the manufactured products valuable qualities not obtained by any other process. M.V.C.

Influence of composition of slips, their preparation, and the fineness of the raw materials before mixing on the structure of stoneware tile. F. CHALAMEL. *Céramique*, **39** [574] 1–7 (1936).—A slip containing feldspar, mixed wet, with materials ground very fine, gives the most fusible and least porous body, but the addition of coarse material decreases cracking. M.H.B.

Physicochemical studies of the manufacture of stoneware. M. LÉPINGLE. *Métaux & Machines*, **19**, 295–96 (1935); abstracted in *Chem. Zentr.*, **i**, 404 (1936).—The phase diagrams of the binary systems, MgO–SiO_2, MgO–Al_2O_3, and the ternary system SiO_2–MgO–Al_2O_3 are discussed. It is important that mixtures of kaolin and MgO, with about 44% kaolin, have a minimum melting point lying near 1300°C, when producing stoneware containing MgO. Stoneware from special mixes are discussed and the deposits, use, and properties of chromite, silicon carbide, and zircon are dealt with. The melting-point curve of kaolin-chromite mixtures has a minimum with about 42% kaolin and a melting point of cone 15. M.V.C.

Weathering of Vindhyan building stone. J. A. DUNN. *Records Geol. Surv. India*, **65** [3] 434–37 (1931); abstracted in *Indian Eng.*, **91** [10] 181 (1932).—A veranda, 14-ft. wide, of the Jumma Musjid, Delhi, India, built by Shah Jehan, was roofed by 9-inch thick slabs of Vindhyan sandstone, and at some date, in order to strengthen the slabs, an 18-in. layer of lime concrete was constructed over them. Recently large pieces of the sandstone were found to be flaking off from the lower surface of the slabs. D. found that, although the rock was not particularly porous, during the rainy season the sandstone pores were filled with water carrying $CaCO_3$ in solution from the lime concrete above. In the dry weather evaporation concentrated the $CaCO_3$ toward the undersurface where it crystallized in the lower 1 in. of sandstone. The growth of the minute $CaCO_3$ crystals forced off thin layers of the stone. In India ceiling and wall plasters are frequently observed to flake off owing to the complete saturation of roofs and walls each monsoon, the salts from the mortar crystallizing behind the plaster and pushing it away from its adhering surface. The destructive effects described can be minimized by applying a waterproof coating to all exposed surfaces. A.P.S.

PATENTS

Production of colored sintered glazes on fired tile or earthenware. I. G. FARBENINDUSTRIE A.-G. Ger. 598,872, Nov. 11, 1935, Kl. 80b, 23/03; *Keram. Rundschau*, **43** [6] 68 (1935). Sublimating metallic chlorides, especially $FeCl_3$, are introduced in the firing chamber. R.W.D.

Roofing tile. WILHELM LUDOWICI. U. S. 2,028,228, Jan. 21, 1936 (April 3, 1933).

Self-fertilizing flowerpot. HARRY STEINBACH (Rex Beach). U. S. 2,028,255, Jan. 21, 1936 (Aug. 23, 1934). A flowerpot having a fertilizer receiving recess near the upper edge of the pot and a solid cake of soluble fertilizer in the recess adapted, when the pot is filled with soil, to be dissolved by moisture in the soil.

Whiteware

Contribution to the study of casting slips. P. DE GROOTE. *Céramique*, **38** [570] 203–11 (1935).—G. reviews the use of aerometers, viscosimeters, and agitators in determining the fluidity of a slip. He suggests an apparatus consisting of two tubes, having flared ends covered with a thin rubber membrane. One of these tubes is oriented downward, the other upward. The tubes, partially filled with a colored liquid to the same level, are immersed in the liquid to be tested. Any solid material will exert an additional pressure on the tube flaring upward. Suspended matter will, of course, exert no additional pressure. The difference in level in the two tubes is then proportional to the settling rate of the material. M.H.B.

Dehydration of slips formed by mixing water with kaolin. R. DUBRISAY. *Céramique*, **38** [573] 259–65 (1935).—D. discusses the colloidal properties of clay and shows their value in use. M.H.B.

Electric insulation with fired steatite. W. Y. CHANG AND Y. M. HSIEH. *Jour. Chinese Chem. Soc.*, **3**, 183–95 (1935); abstracted in *Chem. Zentr.*, **i**, 1068 (1936).—The suitability of 21 Chinese steatite samples for electric insulation was studied. The samples have a linear shrinkage of about 1% and a loss in weight of about 5% on firing to 850°. The suitability of fired steatite for various purposes is discussed. M.V.C.

Electrical conductivity of silica minerals and cut quartz. (in English) H. SAEGUSA AND T. MATSUMOTO. *Sci. Repts. Tôhoku Imp. Univ.*, **24**, 537–50 (Nov., 1935); abstracted in *Science Abs.—A*, **39** [458] 186 (1936).—A slight anomaly was found in the electrical conductivity similar to that of thermal expansion and heat absorption, corresponding to transformation of β-quartz to tridymite. The temperature coefficient of electrical conductivity of the quartz is not affected by its method of cutting. H.K.R.

Experiments in the manufacture of bone china. K. ELEÖD. *Keram. Rundschau*, **43** [17] 191–92 (1935).—E. manufactured excellent bone china with the following recipe: a slip containing 50.9% bone ash, 25.0% Lorient kaolin, and 24.1% Limoges pegmatite is cast in plaster molds (percentages are computed on dry weights). After drying, the pieces are fired in a muffle at cone 9. Only the central parts of bones are used for the preparation of bone ash; gelatinous components are expelled by steam, and bones are fired to a dull red temperature in a muffle kiln. They appear grayish black and later nearly white in the presence of free air. The inside of the bones retains colloidal carbon useful for plasticity and slip casting. The bone ash is finely ground in a wet mill. Milling water is very alkaline; after boiling, this water contains valuable constituents which increase plasticity and strength before firing. Heating lasts 18 hr. in an oxidizing muffle atmosphere, pieces being laid in alumina powder, which is basic and inert in the presence of highly basic bone china. Vitrification is perfect at cone 9. A good, lead-free glaze has the following composition: frit 625 and kaolin 250, the contents of the frit being borax 180, kaolin 33, $CaCO_3$ 90, SiO_2 99, and Limoges pegmatite 90. The slip should never contain more than 26% kaolin; if an addition of ball clay is necessary to secure plasticity, the kaolin must be decreased accordingly. F.E.V.

Gypsum molds and their effect on deformation of porcelain ware. M. V. FLEROV AND A. I. ERMAKOV. *Keram. i Steklo*, **11** [10] 27–29 (1935).—Studies showed that ware deforms in gypsum molds because of a different degree of water absorption in various parts of the mold. Directions for eliminating these defects are given. M.V.C.

Influence of drying treatment and biscuit storage atmosphere on the physical properties of a semiporcelain body. HORACE L. LATIMER AND ARTHUR S. WATTS. *Jour. Amer. Ceram. Soc.*, **19** [4] 121–26 (1936).

Iron titanium spinel as a cause of discoloration of whiteware during firing and its elimination. F. KRAUSS AND R. GRAMSS. *Keram. Rundschau*, **43** [16] 179–81; [17] 192–94; [19] 216–18; [20] 229–33 (1935).—Discoloration of ceramic ware fired in a reducing atmosphere is essentially due to the formation of black spinel, $FeO \cdot Ti_2O_3$. Pure iron titanium spinel was prepared for the first time by the authors. In a reducing atmosphere addition to the raw mix of borax and of phosphate overcame the discoloration of porcelain during firing, but the best and most certain effect was obtained by addition of 3 to 5% $3CaO \cdot 4B_2O_3 \cdot 10$ to $12H_2O$, which was prepared by precipitation in solution. F.E.V.

Swelling of whiteware bodies. G. KEPPELER AND R. PANGELS. *Sprechsaal*, **66** [37] 625–28 (1933).—Studies dealing with (1) the dependence of body swelling on composition and firing temperature, (2) porosity and shrinkage on firing, (3) swelling and combination of water, (4) HCl solubility and swelling, and (5) swelling and hair cracks are described. The swelling is chiefly related to the formation of constituents with a "permutoid" structure. Permutites are silicate materials with a glossy-amorphous structure produced by melting sand, kaolin, feldspar, and soda. M.V.C.

BULLETIN

Swelling of whiteware bodies. R. PANGELS. Dissertation, Hannover, 1934, 43 pp.; abstracted in *Referat. Silikatliteratur*, No. 662 (1934).—P. discusses fundamental researches dealing with the changes in volume of whiteware bodies from the effect of water absorption or absorption of moisture during storing. The dependence of the swelling on composition and firing temperature was studied. It was found that an increase of firing temperature lowers swelling, especially in kaolin, and is not affected by the addition of quartz sand. Lime whiteware bodies free from feldspar expand the least. The particle size of feldspar has a considerable effect on the swelling, while that of quartz is without effect. In general, the swelling of bodies is a peculiarity of fired and porous ceramic materials and can be lowered by an appropriate change of the composition of the mix and firing. M.V.C.

PATENTS

Ceramic structures for use in high-frequency electrical apparatus. TELEFUNKEN GES. FÜR DRAHTLOSE TELEGRAPHIA. Brit. 441,959, Feb. 12, 1936 (Dec. 28, 1933).

Increase of the mechanical resistance of ceramic insulators. OTTO KRAUSE. Ger. 596,745, Feb. 20, 1932, Kl. 21c, 2/01; addition to 503,900; *Keram. Rundschau*, 42

[52] 650 (1934). Crystal glazes are used as high-resistant glazes. R.W.D.

Method of making compact bodies consisting of pure magnesium oxide or beryllium oxide. REINHOLD REICHMANN (Siemens & Halske A.-G.). U. S. 2,033,300, March 10, 1936 (Feb. 20, 1933). As an article of manufacture, a spark plug has an electric insulator made of practically pure oxide material, the material containing Be_3O_3 as a main constituent.

Mold for the manufacture of teapots, etc. F. D. FOLEY. U. S. 2,031,258, Feb. 18, 1936 (April 19, 1935). A teapot mold is divided horizontally into upper and lower sections, the wall of the upper section being pierced by a tubular spout-forming cavity bounded by the wall.

Equipment and Apparatus

Air classification in pulverizing. H. HARDINGE. *Ind. Eng. Chem.*, **26** [11] 1139–42 (1934).—Control of the characteristics of pulverizer products by the integration of the air classifier and mill operation effects economies in grinding to specification. Examples of operation on a variety of products are cited. Illustrated. F.G.H.

Air-conditioning cabinet for research. EDITORIAL. *Indian Eng.*, **91** [9] 172 (1932).—An air-conditioning cabinet, constructed by Air Conditioning Corp., Ltd., is described. Humidity can be controlled within ±2.0% and temperature within ±2°F. There is hardly a material which can not be manufactured best under certain definite atmospheric conditions. Costly experiments are often necessary to discover these conditions and this expense can be largely obviated by the use of the above equipment. A.P.S.

Brickmaking machines: I. J. HAUSEN. *Eng. Progress*, **16** [12] 297–301 (1935).—H. deals with the machines used in preparing the raw materials for brickmaking. The conveyers, rotary feeders, wet and dry pans, mixers, grinders, pug mills, etc., used in German practice are described. 15 photos. J.L.G.

Cinder and fly-ash measurements. P. H. HARDIE. *Combustion*, **6** [3] 10–16 (1935).—Cinder and fly-ash measurements are usually conducted to determine (1) the amount of dust leaving the stacks, (2) efficiency of the dust-separating apparatus, and (3) loss in steam-generating unit efficiency due to solid combustibles carried up with the flue gas. These measurements serve as a guide in improving boiler efficiency by indicating means of reducing the flue-dust loss and developing efficient dust-separating apparatus. H. describes the method and apparatus for investigating the effectiveness of different types of dust-separating equipment. While all the investigations were conducted on stoker-fired installations, the procedure is equally applicable to pulverized-coal installations. **Discussion.** A. C. STERN. *Ibid.*, [10] 37–38.—S. takes issue with Hardie's statement that the testing apparatus and technic are the same for the determination of dust leaving the stack, efficiency of dust-separating apparatus, and the determination of the combustible loss in cinders. **Reply to discussion.** P. H. HARDIE. *Ibid.*, [11] 35. H.E.S.

Competition between the most suitable materials for the design of instruments. B. BLOCK. *Chem. App.*, **23** [1] 1–4 (1936).—The selection and availability of materials used in the construction of instruments and apparatus are discussed from the standpoint of mechanical strength, safety, and endurance. A table shows the mechanical, physical, thermal, physiological, and corrosive properties of metals and nonmetals and their behavior and mode of application. M.H.

Control valves. LAMMERT AND MANN CO. *Instruments*, **9** [2] 55 (1936).—A new line of control or automatic shut-off valves is announced, with interchangeable elements for air, steam-pressure, water-pressure, or electrical control. Any one of these elements is connected by merely screwing it into the standard valve-body mechanism. The valve itself has but two moving parts and is held firmly in position, when closed, by a cadmium-plated spring. The needle and seat are of stainless steel; all other parts are also of "noncorrosive metals." A packless gland is used, in the form of a brass bellows, to minimize friction. R.W.R.

Developments in ore-pulp classification. D. MACLEAN AND C. L. DEWAR. *Jour. Chem., Met., Mining Soc. S. Africa*, **35** [11] 329–43 (1935).—Classification methods on the Rand have been mainly by (1) cone classifier and (2) mechanical classifier of the Dorr type. With the advent of tube milling, cone classifiers were found to have many disadvantages, though a gear for increasing and controlling underflow tonnage remedied some of the difficulties. A more recent development is a "spiral" classifier in which the coarser and heavier particles on the bottom tend to travel inward while the smaller and lighter particles move outward. E.H.McC.

Developments in plant equipment. ANON. *Brick Clay Rec.*, **88** [2] 61–62 (1936).—Developments in drying, control instruments, and power shovels are reviewed. E.J.V.

Developments in platinum thermocouples. B. BRENNER. *Ind. Eng. Chem., Anal. Ed.*, **7** [6] 438–40 (1935).—Definite improvements are described which have been made in the manufacture of platinum-rhodium thermocouples, increasing their effective life, resistance to deterioration at high temperature, homogeneity, and reproducibility. Data are presented to indicate what tolerances are possible for a manufacturer of rare metal thermocouple wire to meet. The tolerances of ±3 microvolts at 1200°C for homogeneity within +2° to 0°C for agreement with the standard values, and a maximum change of 5 microvolts at 1200°C in the completed couple, upon annealing for 6 hr. at 1500°C, are believed to be the closest tolerances ever set up for thermocouples. Manufacturing experience with these tolerances demonstrates that they can be consistently met, however, and this fact should prove valuable to users of rare metal thermocouples as a guide to determine what performance they may reasonably demand. Flash-annealing the platinum at 600°C and the platinum-rhodium alloy at 1200°C is sufficient to stabilize thermocouples of high quality. Intensive annealing does not materially change the e.m.f. and impairs the mechanical properties. Such annealing, moreover, renders the wire more susceptible to contamination during subsequent use. F.G.H.

Device for centering a microprojector lamp. R. HARRIES. *Jour. Sci. Instruments*, **12** [12] 393–94 (1935).—A

method of mounting a lamp on a brass plate equipped with three conical holes through which centering screws pass through springs to the lamp housing in such a manner as to leave the plate floating between springs and screw heads is described and illustrated. Tightening one screw tilts the lamp toward the opposite side of the housing. J.L.G.

Dust control at the Sullivan Mine of Consolidated Mining and Smelting Co. of Canada. J. R. GIBGERICH. *Can. Mining Met. Bull.*, No. 286, pp. 64–69 (1936).—Seven distinct methods of control are practiced, six methods being used underground. These are (1) improved ventilation, (2) general use of water sprays and atomizers, (3) curtailment of secondary blasting during shift hours, (4) 100% wet drilling, both primary and secondary, (5) wearing protective equipment, and (6) change from carbide to electric lamps. Dust collectors have been installed in the crushing plants on the surface. G.M.H.

Dust separation from combustion gases. EDITORIAL. *Indian Eng.*, **91** [13] 252 (1932).—Shunt pressure centrifugal collectors made by Davidson & Co., Ltd., Belfast, are described as installed in the Compañía-Hispano-Americana de Electricidad, Buenos Aires. They are capable of recovering extremely fine ash in spite of the volume of gases concerned, approximately 500,000 cu. ft. for every ton of coal burned. A.P.S.

Elevated conveyer for transporting overburden. ANON. *Engineering*, **139** [3624] 678–79 (1935).—An elevated conveyer is described and illustrated. It conveys overburden from its source to the unused portion of the clay pit. The overburden is dumped in the pit from which the usable clay has been taken, and this involves passing it over the clay face and discharging it well away from the face. The removal of overburden is necessary for the production of good quality brick. H.E.S.

Expansion measurements with X-rays. V. BUSSEM. *Keram. Rundschau*, **43** [17] 196 (1935).—The X-ray method measures directly the expansion of crystalline matter even in the vicinity of the softening point. The recently developed reflection process has increased accuracy to such a point that it can compete with the best macroscopic measurements (errors less than 0.005%). B. has built a conical oven with a negligible temperature gradient at the top of the cone; the test piece and thermocouple always have the same temperature. The kiln is heated by accumulators and Pt-resistors. The X-rays are directed in coincidence with the center line of the cone. Interferences caused by reflected rays are registered on an even film 35 to 80 mm. distant from the test piece. An aluminum sheet 0.01 mm. thick protects the film against radiation; air cooling is eventually used. Variations of lattice distances may be tested between −180° and 1450°C. Expansion curves have been plotted for magnesia, cristobalite, and silicon carbide up to 1400° and for gold and silver to near the melting point. F.E.V.

Fluorescent materials in lamps. ANON. *Electrician*, **116** [2] 34 (1936).—The B. T. H. exhibit of vapor lamps with fluorescent and luminescent materials is discussed. Such minerals are used inside lamps to transform ultra-violet radiation into radiation in the visible range of the spectrum. H.K.R.

Fluorescence microscope, an aid to scientific investigations. A. KARSTEN. *Zentr. Mineral. Geol. A*, 344–48 (1935).—The iron-arc illuminator and the ultra-violet transmitting lenses of a fluorescence microscope are described. H.I.

Fundamental principles of drying. E. A. FISHER. *Jour. Soc. Chem. Ind.*, **54** [42] 344–48 (1935); for abstract see *Ceram. Abs.*, **15** [1] 32 (1936). G.R.S.

Grinding elements of ceramic mixes and all hard materials with water. RAOUL DE BLOTTEFIÈRE. *Rev. mat. constr. trav. pub.*, No. 314, pp. 161–65B (1935).—The Alsing mill is described. It consists of a cylinder with rollers (spherical or ovoid) with interior lining. The rollers fill half the cavity and the peripheral speed is 1.75 m./sec. At this speed the rollers rise to about 45° and fall back similar to ebb-tide. From experiments, the weight of the dry material to be ground must be about half that of the rollers and the charge, a third of the latter. The most favorable length for the cylinder is 1.25 to 1.30 times the diameter. After tests (6 hr. duration) the yield in material passing the 140-mesh screen was the same for an Alsing consuming 6 h.p. and a block mill with a power of 20 h.p. In absolute value, the Alsing treated 550 kg. and the mill 275 kg. M.V.C.

History of pebble mills. PAUL O. ABBÉ. *Amer. Enameler*, **8** [10] 6 (1936).—A. traces the history of the pebble mills from about 1865 to the present time. J.H.S.

Hydraulic command for variable-speed drives. REEVES PULLEY CO. *Instruments*, **9** [2] 49 (1936).—Applicable to maker's variable-speed transmissions of sizes 000 to 8 inclusive, whether new or now in use, this hydraulic unit makes possible continuous automatic control of speed within the limits of the transmission. It is actuated by an indicating lever attached by cable, link, etc., to any element whose displacement is a function of the speed to be controlled. The force required being of the order of 2 or 3 oz. and the minimum displacement required to bring about a change of speed being "a very small fraction of an inch," such available elements as floating rolls, diaphragms (pressure), floats (level), etc., can be used to actuate the lever. The "hydraumatic control" comprises a fractional-h.p. motor continuously driving a geared pump which delivers a steady stream of oil to the pilot arrangement, which is described. The power device proper is a reversible hydraulic motor. The normal time for shifting from one extreme to the other is 35 seconds; mode of control is non-hunting. R.W.R.

Low-lag separable-well tube systems (for temperature recorders and controllers). TAYLOR INSTRUMENT CO. *Instruments*, **9** [2] 49 (1936).—The "Thermospeed" separable-well tube system is said to have a speed response closely approaching that of the manufacturer's fastest bare-bulb systems, approximately six times faster than the average separable-well tube system now in service, and almost twice as fast as separable-well thermocouples. R.W.R.

Manometer errors due to capillarity. RICHARD G. FOLSOM. *Instruments*, **9** [2] 36–37 (1936).—This investigation was undertaken to provide data required for the selection of manometer-tube size when measurements must be within a given limit of error. The material was collected from published reports with the addition of some approximate tests. Simplified formulas of the type given by Gibson and Marks for the capillary rise in small tubes can not

be applied for diameters greater than about 0.1 in. A graph is given for estimating the theoretical rise or depression, and tests indicate these values to be valid for normal engineering conditions. These data permit the selection of manometer sizes for a given error and the estimation of the error when U-tubes of differing internal diameters are used. R.W.R.

Mapping ultra-violet absorption spectra, using a special hydrogen lamp and a microphotometer of simple design. H. C. Gull and A. E. Martin. *Jour. Sci. Instruments*, **12** [12] 379–88 (1935).—A constant output hydrogen lamp provides a continuous spectrum in the ultra-violet. Absorption spectra are photographed with this light source. One exposure gives the solution. A number of exposures are then made for the solvent, starting with that given for the solution and decreasing by degrees to give a suitable range of extinction coefficients. Absorption spectra together with other spectra are recorded with a microphotometer so that the absorption curve is traversed by a series of lines corresponding to known extinction coefficients. The extinction coefficient at any point on the absorption curve can then be read directly from the record. The entire apparatus, including the microphotometer, is described in detail. Illustrated by drawing, photo, and curves. J.L.G.

Measurements on the open-hearth furnace. W. Liesegang. *Arch. Tech. Mess.*, **5** [54] T165–66 (1935).—The correct arrangement for making temperature measurements in furnaces, in particular the open-hearth furnace, is explained; measurements must be made (1) to obtain rapidly the maximum admissible temperature required for the process, (2) to insure the greatest possible uniformity of temperature in the hearth, (3) to prevent the recuperating or regenerating installation from becoming too hot, and (4) to avoid uneconomical utilization of the waste gases. Arrangement and types of instruments to use for temperature, pressure, and draft measurements, for gas and air quantities, and for gas analyses are discussed. 16 references. M.H.

Measuring instrument for lengths. Fr. Benz. *Messtechnik*, **11** [12] 237–38 (1935).—An arrangement based on the measurement of the change of the capacity of a condenser with the change of the length of the piece to be measured is described; the sensitivity is 1/10,000 mm. M.H.

Method of obtaining and controlling high humidities at high temperatures. W. Leathersich. *Jour. Sci. Instruments*, **12** [12] 388–91 (1935).—L. solves the difficulty of obtaining and controlling high humidities in small ovens at temperatures to 100°C by immersing an electric heater in the water pan so that the water can be heated independently of the heating unit of the oven in which it is placed. A detailed discussion of power consumption, temperature, evaporation rate, and relative humidity is given. Any humidity can be obtained at temperatures up to 100°C. Illustrated. J.L.G.

"Micron" dust precipitator. Fraser & Chalmers. *Elec. Rev.*, **118** [3035] 126 (1936).—A device for dry centrifugal separation of grit and dust from fumes, gas, or air is described and illustrated. A series of vortex rings control the degree of separation. J.L.G.

Microscope tilting stage. W. Watson and Sons, Ltd. *Jour. Sci. Instruments*, **12** [12] 397 (1935).—This tilting stage, designed by J. R. Baker, Oxford, is made so that low-, medium-, or high-power objectives can be used to make stereophotomicrographs without any departure from the character of illumination used in ordinary microscope work. The two photomicrographs are made by rotating the specimen through 15° about an axis at right angles to the optic axis between exposures. These positions correspond to the convergence of a normal pair of eyes. Viewing the pictures in a stereoscope gives an appearance of depth and solidity. The tilting stage fastens to the upper surface of the mechanical stage by means of two lugs and a clamping screw. Slides $^1/_3$ mm. thick by 25 mm. square are used. The price is £12 10s. Illustrated. J.L.G.

Optical stress-measuring method. G. Mesmer. *Messtechnik*, **11** [12] 238–41 (1935).—The general principles, manner of application, and apparatus for determining optically interior stresses of materials (Hale-Shaw method) are explained and illustrated by examples. M.H.

Positive-action positioner for control valves. Foxboro Co. *Instruments*, **9** [2] 51 (1936).—Developed to eliminate sticking of air-operated control valves, the "Vernier Valvactor" enables throttling-type air-operated instruments to make small gradual adjustments of the control valve position regardless of friction or hysteresis, even when valve packing is very tight. The positioner can be attached directly to the spring housing of all sizes of "Stabilflo" valves. R.W.R.

Prismatic reflecting micro-balance. L. Oertling. *Jour. Sci. Instruments*, **12** [12] 396 (1935).—The microbalance described has a capacity of 10 g. A prismatic reflecting device gives a magnified reading of a radial graticule attached to the pointer which allows the weighing to be read in thousandths of a milligram up to ±0.1 mg. without the use of riders or fractional weights. A detailed description of the balance construction is given. Balance No. 55/PR. Price £67 10s. Illustrated. J.L.G.

Reasons for cracking of clay when heated. A. V. Luikov. *Izvestiya vsesouiznui teplotekh. Inst.*, No. 3, pp. 43–46 (1935); abstracted in *Chem. Zentr.*, **i**, 139 (1936).—Studies showed that the moisture gradient is an important factor for the formation of cracks in clays on heating in air saturated with moisture. M.V.C.

Selection of mold steel. J. C. Alexander. *Machinery* [London], **47** [1] 469–70 (1936).—A. gives a brief, general discussion of high C-high Cr, low W and Cr, Mn-Cr, Ni-Cr, carbon tool, stainless and mild steel, and soft iron for molds. Characteristics desired are easy machineability, freedom from distortion during thermal treatment, low hardening temperature, intense surface hardness and internal toughness, capacity to take and retain mirror polish, abrasion resistance, nonadherence to molded product, capacity to respond to rapid thermal treatment, and stainlessness. W.H.B.

Simple type of humidity chamber. F. C. Mead. *Jour. Sci. Instruments*, **12** [12] 394–95 (1935).—A small glass-inclosed chamber for electrical tests on small specimens of dielectric material under controlled conditions of temperature and humidity is illustrated. Beakers of sulfuric acid or other suitable solutions are used to secure desired humidities. An inverted glass battery jar may be used for the chamber. Two carbon-filament lamps are used as heaters.

A small fan is used to circulate the air. Controls for heating and thermostat circuits are mounted outside the chamber. J.L.G.

Standardization of index liquids. JEWELL J. GLASS. *Amer. Mineralogist*, **19**, 459–65 (1934).—Immersion liquids should be as nearly colorless as possible, chemically stable, and of low volatility. It is desirable that the entire series be completely miscible, moderately viscous, and mineralogically inert. Government oil and monochlor-naphthalene are ideal ingredients for preparing liquids in the range 1.470 to 1.630, while an addition of methylene iodide to the monochlor-naphthalene affords a means of producing liquids in the range 1.630 to 1.740. These liquids are remarkably stable in refractive indices even after heating to 150° and maintaining that temperature 21 hr. Liquids for the low-range media include *N* decane (1.410), butyl alcohol (1.399), and glycerin (1.462). Methods for standardizing liquids for measuring indices of refraction include the Abbé refractometer and the minimum deviation method with a hollow glass prism mounted on a one-circle goniometer; the latter is described in detail, together with the helium spectrometer lamp, a convenient monochromatic light source. F.J.Z.

Studies in filtration: III, Derivation of general filtration equations. B. F. RUTH. *Ind. Eng. Chem.*, **27** [6] 708–23 (1935).—The mathematical background of a treatment of constant-rate and constant-pressure filtration that has been used with complete satisfaction for several years is established. Although the experimental verification of its various phases must necessarily extend through a series of papers, this fairly complete discussion at the outset is essential to familiarize the reader with the notation and equations to be used throughout. Thereafter it should serve as a valuable compendium for future reference. Mathematical simplicity in relation to the engineering requirements of analysis and design has been the prime objective of this development, yet neither accuracy nor correctness of concept has been sacrificed in its attainment. The fundamental maxim of filtration with its essential postulate that filter septum resistance may be expressed in terms of filtrate volumes has served as the basis for the treatment of constant-pressure filtration. In contrast, it is found just as essential to the simple treatment of constant-rate filtration that this concept be discarded and septum resistance be expressed as a pressure drop. General filtration equations applicable to all prefiltered concentrations are formulated for a number of types of filtrations, and various factors influencing their accuracy are discussed. It is shown that from theoretical considerations the true shape of the time-volume discharge curve may depart slightly from a perfect parabola in the initial stages of filtration. Illustrated. F.G.H.

Technical drying. A. ANTONI. *Chaleur & Ind.*, **16**, 29–48 (1933); abstracted in *Chem. Zentr.*, **i**, 126 (1936).—A. reviews the physical bases and various methods of drying used in industry. M.V.C.

Thermal protection and insulating methods. H. DIEGMAN. *Schweizer Brauerei-Rundschau*, **46**, 175–77 (1935); abstracted in *Chem. Zentr.*, **i**, 841 (1936).—A review is given of the heat-insulating properties of cork, textile fiber, glass wool, mineral wool, magnesia insulation, air and reflection insulation, and diatomite. M.V.C.

X-ray examination of fine structure and its value for surface refinement. A. KUPFERATH. *Oberflächentech.*, **13** [2] 15–16 (1936).—The principle and method of applying homogeneous X-rays for the determination of the crystallogeometric structure, deformation, and recrystallization phenomena in metals, vitreous and ceramic materials, and wood are explained and the apparatus is described. 6 references. M.H.

X-ray powder camera. M. J. BUERGER. *Amer. Mineralogist*, **21** [1] 11–17 (1936).—A detailed diagrammatic description of the powder camera used successfully by B. in conjunction with a Hadding gas tube is presented. F.J.Z.

PATENTS

Brick lifting device. W. J. SULLIVAN (Morris Townley) U. S. 2,033,746, March 10, 1936 (June 1, 1933).

Drying process. BENNO SCHILDE MASCHINENBAU A.-G. Ger. 601,007, Jan. 26, 1933, Kl. 82a, 1/01; *Keram. Rundschau*, **43** [9] 102 (1935). The invention relates to a set of apparatus provided with dampers where goods undergo, in a cyclic operation and in variable pressure conditions, the effect of dry air or of other gaseous medium. R.W.D.

Electromagnetic drive operating a cutting device for sectioning a continuous strip of clay, as in the manufacturing process of tile. CARL RUNGE. Ger. 597,638, Jan. 4, 1932, Kl. 80a, 37; *Keram. Rundschau*, **42** [51] 636 (1934). R.W.D.

Indenting and stamping machine for clay products, such as paving brick, etc. E. D. MATTES (Decatur Brick Mfg. Co.). U. S. 2,031,899, Feb. 25, 1936 (Sept. 17, 1934).

Insulator-forming machine. L. B. HARVEY AND L. L. FRENCH (Porcelain Insulator Corp.). U. S. 2,033,827, March 10, 1936 (Feb. 28, 1931).

Means for the measuring of gloss. W. R. HORSFIELD. U. S. 2,032,128, Feb. 25, 1936 (May 22, 1935).

Measuring system. M. E. LEEDS (Leeds & Northrup Co.). U. S. 2,031,050, Feb. 18, 1936 (Dec. 2, 1932).

Pipe-handling equipment. F. W. BLACK, R. E. LINDEMANN, AND G. M. SCHAULIN (Robinson Clay Product Co.). U. S. 2,032,523, March 3, 1936 (April 5, 1933).

Kilns, Furnaces, Fuels, and Combustion

Behavior of sulfur during coal carbonization. G. THIESSEN. *Ind. Eng. Chem.*, **27** [4] 473–78 (1935).—Approximately 45% of the organic sulfur and 60% of the pyritic sulfur remain in the coke. Iron compounds other than pyrite in the coal, arising either from infiltration or from pyrite oxidation, increase the sulfur retention of the coke. Illustrated. F.G.H.

Brown coal coke for direct firing and in the gas producer. K. SCHULTZE. *Glashütte*, **65** [20] 307–308 (1935).—Satisfactory results were obtained from direct and indirect firing with brown coal coke. The raw brown coal contained at least 50% water. The moisture content of coke briquets was only from 3 to 5%. The high porosity of this coke gave it a high reaction velocity. Because of its fine granu-

lar nature, the material was compressed into briquets and special grates were used. M.V.C.

Capacity of flames of technical gases as characteristic of their burning properties. H. Bruckner and H. Lohr. *Gas- & Wasserfach*, **79** [2] 17–20 (1936).—The specific flame capacity of a gas is defined as that heat capacity which it develops in a standard burner at a definite height of cone as function of the gas-air ratio. The capacity is determined mainly by the capacity of a gas apparatus to heat up in a certain time and by the air-gas ratio. The flame capacities of a number of bituminous coal gases are given for different air-gas ratios; the maximum heat capacity of a flame does not coincide with the theoretical air-gas concentration or with the highest ignition velocity but is shifted toward the side of excess of air. The application of the results to selections of suitable gases and mixtures is explained by examples. M.H.

Coal-ash and coal-mineral matter. G. Thiessen, C. G. Ball, and P. E. Grotts. *Ind. Eng. Chem.*, **28** [3] 355–61 (1936).—Examination of numerous coal-ash analyses indicates that an average of over 95% of coal ash is composed of the four oxides, alumina, silica, lime, and ferric oxides, on a sulfur trioxide-free basis. Petrographic examination of the separable mineral matter from Ill. and western Pa. coals shows that it is composed of over 95% detrital clay, kaolinite, calcite, and pyrite, with other minerals unimportant. Ash-softening temperatures are functions of compositions in terms of the four oxides mentioned, as shown by results of tests on oxide mixtures. Coal-ash compositions occupy a limited part of the quaternary diagram. Of the four faces of the quaternary tetrahedron, one ternary face is known. On this face, ash-cone softening temperatures are related to liquidus isotherms. Methods for estimating ash-softening temperatures are useful if ash analyses are available. A rapid ash-analysis method would be valuable. Clinker formation is affected by mode of occurrence and distribution of the most fusible component in ash. The accelerating influence of pyrites on clinkering is due to the iron oxides formed during its combustion. Iron sulfide has a sharp melting point and gives rise to a very fluid liquid which has no tendency to bind loose particles of coal ash together and is immiscible with fused ash. Illustrated. F.G.H.

Development of the electrical purification of gases. N. Heymann. *Montan. Rundschau*, **27** [10] 1–14 (1935).—H. gives the development of the method and describes the various types of precipitators with wire, plate, and tube electrodes. Installations in Europe alone total over 1000, with more than 3000 individual units, and the method is constantly being extended into new fields. Power consumption of an electric precipitator varies from 0.05 to 0.5 kw.-hr./1000 cu. m. of gas treated, or from 10 to 50% of the power used in a wet or dry mechanical dust-settling plant. Under normal conditions an efficiency of 90 to 98% is attained, with even higher figures where special precautions are taken: 500°C is generally the upper limit for the temperature of the gases treated. Typical installations in various fields are discussed. The first application in the cement industry, for precipitation of K_2O, was in 1907. At the end of 1934, 132 installations were in operation in 64 cement plants, treating hourly 5,400,000 cu. m. of gas (at operating temperature). Dust losses from kilns alone in a cement plant treating 1000 tons daily are from 100 to 160 tons. An installation of 10 to 15 kw. is sufficient to precipitate this dust. B.H.S.

Dry cleaning of steam coal in South Wales. W. Brynmor Davies. *Proc. S. Wales Inst. Engrs.*, **51** [1] 21–76; [2] 105–11, 139–42 (1935). A.H.E.

Electric muffle ovens. Anon. *Russ. Berichte*, Vol. 2, No. 4 (1933); abstracted in *Referat. Silikatliteratur*, No. 378 (1934).—The development of electric muffle ovens is described. M.V.C.

Evaluating the quality of generator gas. Oscar Knapp. *Glashütte*, **65** [36] 561–64 (1935).—Processes occurring during the generating of gas, its composition, and properties are discussed in detail. The chief properties showing the usability of a gas for firing are (1) heat of combustion, (2) its capability of convecting and radiating, (3) rate of combustion, (4) degree of decomposition of steam, and (5) its effect on the refractory wall. M.V.C.

Firing Stalinogorsk clays in Hoffman kilns. B. N. Gak. *Ogneuporui*, **3** [9] 690–95 (1935).—The high percentage of carbonaceous material in the clay led to difficulties in the regulation of the firing process and to the formation of "black zones" in the brick. Equipping Hoffman kilns with air-blasting devices permitted improvement of the quality of the brick. P.B. & E.S.

High-temperature carbonization of coal. J. D. Davis and S. Auvil. *Ind. Eng. Chem.*, **27** [4] 459–61 (1935).—The effect of free space above the charge on the yields and properties of gases and tars obtained in high-temperature carbonization is discussed. F.G.H.

Importance of the work schedule in running gas-producer stations. N. A. Migulin. *Ogneuporui*, **3** [9] 695–700 (1935).—The practice of a refractories plant is discussed. P.B. & E.S.

Industrial uses of electric furnaces. R. M. and S. F. *Rev. ind.*, **66** [2318] 19–22 (1936).—The resistance-type electric furnace is being extensively used in various industries where all kinds of ware undergo heat treatment at temperatures not exceeding 1400°C. R.W.D.

Investigation of an Ekkardt hot-top gas chamber kiln. P. I. Soldatov and S. M. Baranskiĭ. *Ogneuporui*, **3** [9] 684–89 (1935). P.B. & E.S.

Natural coke. M. M. Mukherji. *Quart. Jour. Geol. Mining Met. Soc. India*, **6** [4] 83–98 (1934).—M. discusses the origin, character, and X-ray examination of natural coke, or *Jhama*, or burnt coal (a term used in the Damuda valley coal fields for the caked coal of seams intruded by dykes and sills of mica-peridotite) in the seams known as 13, 14, 15, and 16 in the Karee Jore River section of the Kusunda-Kustore area in the Jherria coal fields. He concludes that the hard metallurgical coke made in modern by-product recovery ovens from the same coal (but not from the region of dykes and sills) would be superior to the natural coke because of the uniformity in composition, lower volatiles, lower ash, lower phosphorus, higher porosity, and better reactivity and conductivity of the former type. A.P.S.

Opportunity for cost reduction in small tunnel kilns. R. B. Keplinger. *Brick Clay Rec.*, **88** [2] 59–60 (1936).—The largest return on investment and also the largest reduction in operation costs could be achieved in plants

by re-designing and rebuilding driers, and by installing regenerative tunnel-kiln equipment, particularly if the latter were tied up to the manufacturing process so that the brick could be hacked directly from the belt onto the tunnel kiln cars. Coal, if used, should be used by stoker installation. There must be closer control on the drier to achieve the full benefits of de-airing, to eliminate waste, and improve quality. E.J.V.

Producing ceramic resistors for electric furnaces. K. A. KARAVANOPULO. *Ogneuporui*, **3** [7] 516–20 (1935).—The batch consisted of silicon carbide, Nos. 180, 220, 250, and 320, and crystalline silicon screened through 4900-mesh/cm.^{2} in the proportion 4:4:4:4:9 for rods. For tubes the batch contains, equal quantities of Nos. 120 and 150 silicon carbide and crystalline silicon screened through 576- and 4900-mesh/cm.^{2} were used. The service of the rods at 1200° is 1000 hr. and more. P.B. & E.S.

Pyrolysis of coal: thermal decomposition and distillation of a coal in high vacuum. B. JUETTNER AND H. C. HOWARD. *Ind. Eng. Chem.*, **26** [10] 1115–18 (1934).—An evaporative still is described which has been designed for the pyrolysis of bituminous coal at temperatures up to 620°C and at pressures of 10^{-2} to 10^{-3} mm. of mercury. Detailed studies of the vacuum distillation of a Pittsburgh bed coal from the Edenborn mine are presented. Illustrated. F.G.H.

Recuperators. E. T. *Verre & Silicates Ind.*, **6** [26] 454–56; [27] 469–72 (1935).—A modern recuperator must have a large heating surface for the space occupied and light weight. The refractory walls separating the gas currents must be thin but sufficiently strong; joints must be tight, and the recuperator must be easily controlled and cleaned and its setting up simple. The Teisen hexagonal recuperator is described and compared with other recuperators. Its application to pot and tank and enameling and ceramic furnaces is discussed. M.V.C.

Relation of microscopic composition of coal to chemical, coking, and by-product properties. G. C. SPRUNK AND R. THIESSEN. *Ind. Eng. Chem.*, **27** [4] 446–51 (1935).—The chemical analyses of pure coal-forming constituents or ingredients, such as anthraxylon, spores, opaque attritus (splint-forming material), and fusain, differ considerably. The greatest variation occurs in proximate analyses, hydrogen contents, and calorific values. A microscopic study of column samples of coals from different localities shows that each column is composed of layers of different types of coal of unlike petrographic composition. Comparison of these layers or types from a single column shows wide variations in proximate analyses, calorific values, coke yield, tar yield, ash-fusion temperatures, and agglutinating values. Illustrated. F.G.H.

Specific heats and calorific values of various fuel and furnace gases. FRITZ SCHUSTER. *Wärme*, **58**, 39–40 (1935).—The specific heats and calorific values are given for H, O, N, CO, CO_2, SO_2, H_2O, CH_4, and C_2H_2. These have been recalculated for temperatures up to 1700°. A curve compares the new values with those given previously in the literature. W.H.B.

Washing coal by gravity separation: the Chance sand process at Deep Navigation Colliery, Treharris. JOHN GRIFFITHS. *Proc. S. Wales Inst. Engrs.*, **51** [3] 199–233 (1935). A.H.E.

BOOK

Natural history of Indian coal. CYRIL S. FOX. *Mem. Geol. Surv. India*, **57**, 283 pp. (1931).—Price Rupees 9/4/- or 15s 6d. F. discusses the origin, mode of occurrence, physical and chemical characteristics, and formation of Indian coal. His conclusions on formation of Indian coals are as follows: (1) coal is formed largely from terrestrial plant material; (2) plant material is rapidly submerged under water; (3) conversion into coal takes place in fresh and salt water; (4) transformation is a relatively rapid process; (5) chemical action (not bacterial agency) is the chief factor; (6) formation of coal only takes place in the absence of air; (7) mineral solutions and catalytic agents appear unnecessary; (8) the sap may be the essential agent in coal formation; (9) the quality of the coal is dependent on freedom from "ash"; and (10) the type of coal depends on geological age and pressure. A. P. SOM

PATENTS

Manufacture of silicon carbide resistors. A. J. THOMPSON (Globar Corp.). U. S. 2,032,077, Feb. 25, 1936 (Nov. 17, 1931; July 6, 1935). The method of producing silicon carbide resistors having different specific resistances comprises applying to the resistors a slurry containing silica and a conducting material which is a chemical constituent of silicon carbide, curing the resistors by passing an electric current through the resistors, and producing separate batches of resistors having different specific resistances by changing the ratio of the silica and the conducting material in the slurry applied to the batches.

Rotary drying kiln with inside baffles causing a dispersion of the material being treated. EMIL W. WEISS. Ger. 599,085, May 7, 1932, Kl. 82a, 21/01; *Keram. Rundschau*, **43** [6] 68 (1935). R.W.D.

Geology

Anomalies in the analytical determination of water in epidote. A. F. SMETHURST. *Mineral. Mag.*, **24** [150] 173–79 (1935).—Analyses of several samples of epidote showed a low value for H_2O and a low sum. Only prolonged heating in a silica tube at 1000°C with sodium tungstate sufficed to remove H_2O completely. H.I.

Application of clay mineral technic to Illinois clay and shale. R. H. BRAY, R. E. GRIM, AND P. F. KERR. *Bull. Geol. Soc. Amer.*, **46** [12] 1909–26 (1935).—The authors give a description of other methods and a proposed technic. The technic consists of (1) treatment removing easily soluble materials and exchangeable bases to permit adequate suspension of colloid fractions; (2) dispersion and sedimentation to remove the particles smaller than 1 micron in diameter, followed by fractionation with the supercentrifuge; (3) optical study with the petrographic microscope; (4) X-ray diffraction photography of the prepared fractions; and (5) chemical analysis. Illustrative examples are given. Quartz sericite and kaolinite can be identified as small as 0.6 micron in radius. Beidel-

lite is concentrated in the finest colloid fraction, and Fe_2O_3 in fine colloid fraction. A.C.B.

Bauxites of Lika, Czechoslovakia. GEO. EMELIANOFF. *Compt. rend.*, **201** [26] 1405–1407 (1935).—Geological and tectonic conditions are described. M.H.

Chainuit deposits of kyanite in the Yakut A.S.S.R. K. N. OZEROV AND N. A. BUIKHOVER. *Ogneuporui*, **3** [9] 706–12 (1935).—The deposit is large; the kyanite is similar to Indian "P.B. Sillimanite" and is accompanied by high-grade corundum. P.B. & E.S.

Chattanooga shale in Osage County, Oklahoma, and adjacent areas. CONSTANCE LEATHEROCK AND N. W. NASS. *Bull. Amer. Assn. Petroleum Geol.*, **20** [1] 91–101 (1936).—The Chattanooga (Devonian ?) shale is a widespread, thin, uniform formation of black and gray shales whose exact age relationship is not known. It is absent locally in Osage and Kay counties, Okla., and adjacent counties of Kansas. G.M.H.

Colloidal clay. ANON. *Engineering*, **140** [3633] 220 (1935).—The wide and varied uses of colloidal clay and bentonite are presented and discussed. H.E.S.

Concentration of titaniferous iron ore from Taberg, Sweden, after previous heating. G. G. BRING AND P. G. KIHLSTEDT. *Jernkontorets Ann.*, **119** [8] 303–42 (1935); abstracted in *Jour. Iron Steel Inst.*, **132** [2] 325 (1935).—Ore from Taberg is of the titaniferous type in which the magnetite grains show lamellar intergrowths of ilmenite; the lamellas are so thin that concentration by mechanical means is not possible. Furthermore, a rim of tough hornblende binds the magnetite to the gangue (chiefly olivine), making separation difficult. Attempts were made to effect a separation by heating the ore to temperatures up to 1100°C and quenching it in water. Heating to 1000°C renders the material friable, but at the same time magnetite is formed in quite large quantities in the hornblende, making the gangue strongly magnetic. On the other hand, the magnetite grains themselves become more feebly magnetic. Magnetic separation then becomes difficult, and heating does not, therefore, form a solution to the problem.

Critical review of data for a revision of the enstatite-hypersthene series. ROBERT WALLS. *Mineral. Mag.*, **24** [150] 165–72 (1935). H.I.

Densities of rocks calculated from their chemical analyses. REGINALD A. DALY. *Proc. Nat. Acad. Sci.*, **21** [12] 657–63 (1935).—After reduction of the analysis figures to 100% including water, the norms ("standard" mineral compositions) are calculated (see also Washington's tables). The percentage of each standard mineral is then multiplied by the specific gravity of that mineral. Densities taken from Iddings are listed for 20 common rock-forming minerals. The sum of the products represents the normative density of the rock, supposedly anhydrous. Correction for H_2O+ (arbitrarily assumed to enter as a free phase) gives a normative density almost exactly equaling the actual density. The results of large numbers of tests of the method checked by actual density determinations are shown in four tables. The method appears to give results checking with actual densities within about 1% for the average. The poorest checks are about 6% off. Sources of error and specific applications of the method are discussed. 11 references. J.L.G.

Diatomites of the Dmitrov district. A. V. ZNAMENSKII. *Stroitel. Material.*, No. 8, pp. 45–49 (1935). P.B. & E.S.

Discovery of bentonite in Europe. W. H. TWENHOFEL. *Jour. Sed. Petrology*, **5** [3] 145 (1935).—Bentonite, derived from volcanic ash, has been discovered in the Miocene of Poland. G.M.H.

Feldspar in Rumania. FRANZ KERNBAUER. *Montan. Rundschau*, **27** [8] 7–8 (1935).—Rumania had no production of feldspar prior to the World War. Production was started in 1922 and reached a total of 8044 metric tons in 1929, sufficient for domestic requirement with a small surplus for export. During the depression years the output has dropped to a few hundred tons annually. B.H.S.

Field photography for geologists. F. T. THWAITES. *Bull. Amer. Assn. Petroleum Geol.*, **20** [2] 186–214 (1936).—Some of the basic principles of photography, materials used, apparatus adapted to the geologist's needs, and hints on proper practice are outlined. Particular attention is given to the use of filters. G.M.H.

Flotative separation of fluorspar from calcite. ANON. *Berg- & Hüttenmännisches Jahrbuch*, **83** [3] 109–12; [4] 133–36 (1935).—A particularly suitable agent for a differential flotation was found in chromium nitrate which exerts a pressing action in the flotation liquid and permits the use of sodium oleate as collector for the fluorspar. In general, the experiments also showed that mineral mixtures in which mineral compounds with the same cation exist can be separated. 12 references. M.H.

Frequency determination of detrital quartz and feldspar. R. DANA RUSSELL. *Jour. Sed. Petrology*, **5** [3] 109–14 (1935).—Certain types of detrital quartz grains may be confused with some of the plagioclase feldspars, particularly with oligoclase and andesine. These grains are quite common in some sediments. A simple staining method is described by which a distinction can be made. G.M.H.

Ganophyllite and zincian amphibole from Franklin Furnace, New Jersey. W. F. FOSHAG. *Amer. Mineralogist*, **21** [1] 63–67 (1936).—The composition of ganophyllite ($7MnO{\cdot}Al_2O_3{\cdot}8SiO_2{\cdot}6H_2O$) evidently is variable; it is the manganese end-member of an isomorphous series with stilpnomelane, the iron member. The chemical, physical, and optical properties of ganophyllite, stilpnomelane, and a zinc amphibole are presented. F.J.Z.

Geology of glauconite. E. WAYNE GALLIHER. *Bull. Amer. Assn. Petroleum Geol.*, **19** [12] 1569–1601 (1935).—In Monterey Bay, Calif., glauconite replaces biotite in sediments as they are followed off shore to deeper water. The sediments are derived from granitic and metamorphic rocks. Glauconite is found near land masses where plutonic and metamorphic rocks are exposed and is universally distributed because it forms from a widely distributed mineral, biotite. G.M.H.

Hydrogen-ion concentration of clays and their efficiency as dehydration catalysts. E. O. WILSON AND C. Y. LIN. *Bull. Geol. Surv. China*, No. 20, pp. 55–64 (1933).—The p_H of 36 clays as determined by the H electrode was 3.64 to 8.25 and by the quinhydrone electrode 4.29 to more than 7.20. Four clays of high p_H and four of low p_H were used as catalytic agents for the dehydration of ethyl alcohol.

All gave a high percentage of C_2H_4. No relation exists between p_H and dehydrating property. A.H.E.

Influence of chemical factors on the crystallization of hornblende in igneous rocks. W. Q. KENNEDY. *Mineral. Mag.*, **24** [151] 203–207 (1935) .—The MgO–CaO–FeO ratios of pyroxenes and magmatic hornblendes show marked and characteristic differences. The ratios of the oxides in the original melt constitute a determining factor in the separation of pyroxene or hornblende. The influence of the volatile constituents in the magma is an unknown quantity, but the presence of water can not alone control the ferromagnesian crystallization. H.I.

Kaolinitic weathering of feldspathic rocks: V. A. VASEL. *Zentr. Mineral. Geol. A*, pp. 13–15 (1936).—The differences in plasticity and other physical properties of clay and kaolin are ascribed to the difference in size of the molecules, the clay molecule being $2Al_2O_3{\cdot}4SiO_2{\cdot}3H_2O$ and the kaolin $6Al_2O_3{\cdot}12SiO_2{\cdot}9H_2O$. Kaolin is derived from potash feldspar and clay from soda feldspar. The presence of soda-lime feldspars in the original rocks introduces allophane after weathering which greatly increases the plasticity. H.I.

Microscopic study of the bauxite deposit in the Tzechuan-Poshan district, central Shantung. C. Y. HSIEH. *Bull. Geol. Surv. China*, No. 25, pp. 55–62 (1935). A.H.E.

Microscopic, X-ray, and chemical investigation of a Liassic clay from Dobbertin. F. K. SCHLÜNZ. *Chem. Erde*, **10**, 116–25 (1935).—The fractions obtained by sedimentation of a Liassic clay in Mecklenburg were examined. As previously found for two other clays (*Ceram. Abs.*, **13** [5] 131 (1934)) the content of quartz and feldspar decreased and that of muscovite, SiO_2, and Al_2O_3 increased with decreasing grain size. The electrolyte content was determined. The fraction less than 1 micron was found to contain important amounts of halloysite by X-rays. H.I.

Mineralogical classification of igneous rocks: a comparison of recent proposals. S. J. SHAND. *Jour. Geol.*, **43** [6] 609–17 (1935).—The tendency is to use two instead of three textural divisions and actual instead of calculated feldspar. Various usages of degree of saturation with silica and grouping of dark-colored silicates are given. A.C.B.

Nepheline syenite, a new batch material. CANADIAN NEPHELINE, LTD. *Glass Ind.*, **17** [3] 80 (1936).—Nepheline syenite, an igneous rock consisting of orthoclase, nephelite, and one or more of the following minerals, hornblende, augite, and biotite, is available as a glass batch material. The chemical composition of the rock, now being produced is approximately as follows: silica 59.43, alumina 24.52, iron oxide 0.06, titania 0.01, phosphorus 0.02, lime 0.27, magnesia 0.02, sodium oxide 0.91, and potassium oxide 5.10%; ignition loss 0.44%. Due to the high alumina and low iron content of this material, its use as a source of alumina in many types of glass seems promising. E.J.V.

Occurrence of chondrodite in the Glenelg limestone of Inverness-shire. H. H. READ AND I. S. DOUBLE. *Mineral. Mag.*, **24**, 84–89 (1935).—Chondrodite occurs as small granules forming rims around forsterite crystals. It is suggested that the chondrodite has been produced from forsterite by the accession of fluorine- and hydroxyl-bearing fluids. H.I.

Plasticity of finely ground minerals with water. EARL O. WILSON. *Jour. Amer. Ceram. Soc.*, **19** [4] 115–20 (1936).

Potassium sulfate from polyhalite. E. P. SCHOCH. *Ind. Eng. Chem.*, **27** [4] 467–73 (1935).—Since the discovery of minable beds of pure polyhalite in Texas in 1926, S. has developed four processes for the manufacture of commercial products from it which are progressively of better economic promise. The first three processes are reviewed. Polyhalite appears to be economically usable. Illustrated. F.G.H.

Quartz of Baveno. PAOLLO GALLITELLI. *Periodico Mineral.*, **6**, 105–28 (1935); abstracted in *Chem. Zentr.*, ii, 3896 (1935).—The origin and characteristics of quartz of Baveno are dealt with. M.V.C.

Selenium, a new metal. EDITORIAL. *Indian Eng.*, **291** [26] 511 (1932).—The article describes the uses of selenium, a new metal now included in Canadian mineral products, in the glass industry as a colorizer and for neutralizing other colors, in the pottery industry for the same purpose, and in other industries. It occurs in association with sulfur compounds, often accompanying sulfides of heavy metals in the form of selenides, and also in the slime or residue of electrolytically refined copper. A.P.S.

Silica-fluorite pseudomorphs. JOSEPH MURDOCH. *Amer. Mineralogist*, **21** [1] 18–32 (1936).—An occurrence of silica-fluorite pseudomorphs, closely related to intrusions of basalt, has been observed in Los Angeles County, Calif. The prevalent form is a simple cube, with an occasional modifying tetrahexahedron (210). A rather odd form of built-up or "platy" cubes was observed at one locality. The material of the pseudomorphs is chiefly a finely fibrous silica, either "feathery" or intricately interlocking aggregates of fibrous grains. In part the silica is in the form of normal quartz grains which may be more or less replaced by later fibers. A distinct zonal arrangement is not uncommon. Optical and X-ray evidence leads to the conclusion that the apparently different fibrous forms of silica are due to variant orientations of microcrystalline quartz. Formation of the pseudomorphs is due to replacement from the outside, the exact character of the resultant silica depending on the precise conditions of temperature and concentration at the time of deposition. Warmer solutions are supposed to be responsible for the formation of quartz grains rather than of chalcedony, and continued deposition of silica, with falling temperatures, has allowed replacement of earlier formed quartz grains by chalcedony. F.J.Z.

Silica in soluble silicate cleansers. J. G. VAIL. *Ind. Eng. Chem.*, **28** [3] 294–99 (1936).—The deflocculating action of silicate solutions upon ball clays and kaolin is described and illustrated. F.G.H.

Silicates. V. C. *Verre & Silicates Ind.*, **6** [27] 474–75 (1935).—Silicates are divided into (1) anhydride silicates (feldspars, amphiboles, pyroxenes, gems, micas) and (2) hydrated silicates (zeolites, chlorites, serpentines, kaolins). M.V.C.

Specific gravity and porosity of Indian building stones. G. DE P. COTTER. *Records Geol. Surv. India*, **66** [3] 348–55 (1933).—Tables are given. A.P.S.

Steatite materials. B. M. TAREEV. *Russ-deut. Nachr. Wiss. Tech.*, No. 5, pp. 34–36 (1935); abstracted in *Chem.*

Zentr., **i**, 128 (1936).—T. gives the analysis of steatite from Gopfers-grün, its properties, and its working into new products, such as Melalite, Sipa, Calit, Calan, Ultracalan, and Kerefar. See also *Ceram. Abs.*, **14** [9] 234 (1935). M.V.C.

Studies on zeolites: VIII, Theory of the vapor pressure of the zeolites and of the diffusion of water or gases in a zeolite crystal. MAX H. HEY. *Mineral. Mag.*, **24** [150] 99–130 (1935).—A theory is developed, based on the assumption that the water in the zeolites occupies a definite integral number of lattice positions per unit cell which need not all be filled and that the water is readily mobile since the binding energy is not very large. An equation is derived for the dissociation pressure of a zeolitic compound of a volatile and a nonvolatile component. Values obtained from the equation are found to fit reasonably well the diffusion data on heulandite obtained by Tiselius (*Z. phys. Chem. A*, **169**, 425 (1934)). The theory developed applies not only to the zeolites but to members of the class known as "zeolitic compounds" composed of a volatile and nonvolatile component from which the volatile component can be removed in whole or in part, without the collapse of the structure. For Part VII see *Ceram. Abs.*, **14** [3] 81 (1935). H.I.

Feldspar twinning in a differentiated sill. WINIFRED M. CHAPMAN. *Amer. Mineralogist*, **21** [1] 33–47 (1936).—The observation has frequently been recorded that certain twinning laws (as for pericline) are more commonly encountered in basic rocks, while other laws are especially characteristic of acid rocks. As a follow-up on this observation and in a search for the causes that control twinning, a suite of thin sections taken from the bottom to the top of a differentiated sill was studied statistically to determine whether there are any variations in the nature of the twinning with change in composition of the rock. Over 1400 twins were examined. They showed a statistical increase in the number of twins with increase in basicity, or anorthite content, of the sill. They indicated that there is no change in, or control of, the type of twinning law with the composition of the rock as it appears after crystallization. Another factor still unknown, and not composition, must be responsible for the variation in twinning in different types of rocks. F.J.Z.

Suvorovka clays. A. D. FEDOSEEV AND V. PETROVA. *Ogneuporui*, **3** [7] 533–43 (1935).—A detailed description of the deposit (near Moscow) and characteristics of the properties of the clays are given. They can be used for the production of refractories. P.B. & E.S.

Sylvania sandstone of northwestern Ohio. J. E. CARMAN. *Bull. Geol. Soc. Amer.*, **47** [2] 253–66 (1936).—C. describes pure quartz rock of rounded grains 2 to 3 mm. in diameter. An outcrop map and histograms are given. Glass sand is worked near Rockwood, Mich., where thickness is 50 to 75 ft. It is of eolian and marine origin. A.C.B.

Thermal treatment of the Pingyang alunite. K. Y. KING AND C. C. HSIAO. *Bull. Geol. Surv. China*, No. 23, pp. 31–37 (1933). A.H.E.

Titanium and zirconium in the rock-forming silicates. WILHELM KUNITZ. *Neues Jahrb. Mineral. Geol.*, **70A**, 385–466 (1936).—A review of the literature on the rôles of Ti and Zr in natural silicate minerals is given. Ti may substitute for Si, Al, or Mg, depending upon the character and amounts of other elements in the mineral. The difference in ionic radius of Ti and Si prevents more than a limited replacement in the close-packed olivines and rhombic pyroxenes. Where a simultaneous replacement of Mg by Ca takes place, as in the common augites or the H_2O-bearing hornblendes, larger amounts of Ti may enter the crystal lattice. The type of mineral carrying Ti or Zr depends upon the conditions of temperature, pressure, and concentration at which the minerals crystallize. A tabular arrangement of the Ti-bearing silicates and their relation to differentiation series in rocks is given. H.I.

Viewpoint of science regarding the production and utilization of nonmetallic minerals. C. W. PARMELEE AND J. E. LAMAR. *Ceram. Age*, **26** [2] 53 (1935).—The challenge to science with respect to the production and utilization of nonmetallic minerals is as follows: (1) accumulation of data regarding the location and physical aspects of nonmetallic resources for the purpose of charting supplies for existing uses and for other uses as they may appear; (2) securing detailed chemical, physical, ceramic, and mineralogical data regarding nonmetallic resources; and (3) use of these data for the development by research of new mineral products and the improvement of existing products. F.G.H.

BOOKS AND BULLETINS

Andalusite sands of the Western Transvaal. F. C. PARTRIDGE. *Union S. Africa, Dept. Mines, Geol. Series, Bull.* No. 2, 16 pp. (1934). A.H.E.

Diatomite (Le Kieselguhr. Les diatomées, leur emploi dans l'industrie). J. VANDEN BROECK. Société des Silices fossiles de France, Paris. 114 pp., illustrated. Price 25 F. R.W.D.

Introduction to the Study of Colonial Minerals (Introduction aux études minières coloniales). BUREAU D'ÉTUDES GÉOLOGIQUES ET MINIÈRES COLONIALES, Paris, 1934. 349 pp. Abstracted in *Jour. Geology*, **43** [6] 669 (1935). A.C.B.

Magnesite and hydromagnesite in British Columbia. A. M. RICHMOND. *Brit. Columbia Dept. Mines, Non-Metallic Mineral Invest., Rept.* No. 5, 21 pp. (1933).—British Columbia has ample reserves of magnesite. Present markets are small. Large Fe ore reserves in the province lead to the hope that a local Fe and steel industry may be developed for which refractories would be needed. A.H.E.

Mining operations in the Province of Quebec during 1932. A. O. DUFRESNE. *Ann. Rept. Quebec Bur. Mines*, **1932**, Part A, 158 pp. The report is statistical and descriptive, including many ceramic materials. *Ibid.*, **1933**, Part A, 175 pp. A.H.E.

Travertine deposits near Port St. Johns. W. KUPPERBURGER. *Union S. Africa, Dept. Mines, Geol. Series, Bull.* No. 4, 15 pp. (1935). A.H.E.

Undeveloped clay deposits of British Columbia. A. M. RICHMOND. *Brit. Columbia Dept. Mines, Non-Metallic Mineral Invest., Rept.* No. 4, 36 pp. (1932).—Data are given on ceramic tests of samples of clay from undeveloped deposits. High-grade clays are available for refractory, structural, and ceramic ware but at considerable distances from centers of consumption. A.H.E.

PATENTS

Art of removing metals as volatile chlorides from ores, etc. CHARLES HART (Peter Shields). U. S. 2,030,868, Feb. 18, 1936 (April 21, 1934). The method of separating values of chromium, iron, and nickel from an ore containing chromite and oxide compounds of iron and nickel, the quantity of iron being predominant, in the presence of large quantities of silica and alumina as gangue, includes the steps of effecting a sponging reduction at substantially 1000°C of at least part of the iron and nickel, heating the sponge in the presence of chlorine at a temperature between 500 and 1000° and in the absence of any quantity of reducing agent sufficient to effect reduction of the chromite, silica, and alumina, whereby to provoke a driving off of iron and nickel as chlorides, fractionally condensing the vapors to separate the iron and nickel as chlorides, and again heating the residue in the presence of chlorine and a reducing agent to drive off the chromium as chromium chloride.

Chemistry and Physics

Analysis of limestone. ANON. *Paper Trade Jour.*, 95 [18] 37–38 (1932).—A tentative standard method of the Technical Assn. of the Paper and Pulp Industry is given; sampling and chemical analyses procedures are discussed. C.B.J.

Analysis of salt cake. ANON. *Paper Trade Jour.*, 97 [18] 33–35 (1933).—Tentative standard methods for the Non-Fibrous Materials Testing Comm. of the Technical Assn. of the Paper and Pulp Industry and the procedure for complete analysis are given. C.B.J.

Analysis of sulfur. ANON. *Paper Trade Jour.*, 95 [18] 38–39 (1932).—A tentative standard method of the Technical Assn. of the Paper and Pulp Industry on the sampling and analysis of sulfur is discussed. C.B.J.

Analysis of water. ANON. *Paper Trade Jour.*, 97 [18] 36–39 (1933).—A tentative standard method of water analysis approved by the Non-Fibrous Materials Testing Comm. of the Technical Assn. of the Paper and Pulp Industry is given; reagents, procedures, notes, form of report, factors, and special determinations are discussed. C.B.J.

Calculations of ceramic masses. LEON FRANCQ. *Verre & Silicates Ind.*, 6 [25] 442–45 (1935).—Formulas are given for the calculation of the chemical and molecular composition of ceramic mixes. M.V.C.

Chemistry of the "percompounds": III, New studies on "persilicates." F. KRAUSS AND C. OETTNER. *Z. anorg. allgem. Chem.*, 223 [3] 345–70 (1935).—The following persilicates were prepared: $Na_2SiO_2{\cdot}2H_2O_2{\cdot}H_2O$, $LiSiO_3{\cdot}H_2O_2{\cdot}H_2O$, $BaSi_2O_5{\cdot}2H_2O_2{\cdot}3H_2O$, and $CaSiO_4{\cdot}H_2O_2{\cdot}4H_2O$. Upon storing hydrated silica in H_2O_2 a persilicic acid, $SiO_2{\cdot}H_2O_2{\cdot}2H_2O$, was made. L.T.B.

Color changes of zircon on heating. K. CHUDOBA. *Deut. Goldschmiede-Ztg.*, 38, 474–75 (1935); abstracted in *Chem. Zentr.*, i, 1199 (1936).—Zircons from Mongka decolorized by the sun obtain a bright red color on heating to 110°. The color remains unchanged with slow or rapid cooling in darkness; when cooled in the sun the color disappears; the same is true of those exposed to sun after cooling in the dark. When heated to over 110° the red color turns brown. With subsequent heating the crystals decolorize and can not be colored again. Zircons of different origin behave differently. M.V.C.

Critical temperature of water and of aqueous solutions of sodium silicate. N. I. CHITAROV AND L. A. IVANOV. *Zentr. Mineral. Geol. A*, No. 2, pp. 46–54 (1936).—The determination of critical temperature depends upon the tilting into a horizontal position of a hermetically sealed tube partially filled with the solution at the moment the contents of the tube become a homogeneous phase. The tube swings freely on knife edges and is contained in a furnace. The results obtained give 374°C as the critical temperature of water, 392°C as the critical temperature of a 0.5*N* solution of Na_2SiO_3, and 401°C as the critical temperature of a *N* solution of Na_2SiO_3. H.I.

Densities and chemical compositions of the plagioclase feldspars on a ternary basis. K. CHUDOBA. *Zentr. Mineral. Geol. A*, No. 1, pp. 1–7 (1936).—With the aid of Tschermak's equation as extended to potash-bearing plagioclases, the densities were calculated on a ternary basis. The theoretical densities of the end members, albite, anorthite, and microcline, were calculated by an analytical-geometrical method. Slight departures of observed values of the feldspars from the theoretical were ascribed to a low theoretical value for the density of microcline and to the unlike molecular volumes of the end members. H.I.

Determination of calcium as oxide. A. IEVINS. *Latvijas Univ. Raksti [Riga]*, 2, 465–72 (1935); abstracted in *Chem. Zentr.*, ii, 3802 (1935).—The precipitate of Ca-carbonate or oxalate calcined over a Bunsen burner or blast may contain up to 1% SO_3 because of contact with flame gases containing SO_2. When Ca is to be determined quantitatively as oxide, it is recommended to calcine the precipitate in an electric furnace. M.V.C.

Determination of iron by colorimeter. ANON. *Verre & Silicates Ind.*, 6 [25] 446 (1935).—The method of determining Fe by colorimetry with ferric sulfocyanide is given and criticized. M.V.C.

Determination of manganese and magnesium in soils and silicate rocks. L. A. DEAN AND E. TRUOG. *Ind. Eng. Chem., Anal. Ed.*, 7 [6] 383–85 (1935).—The precipitation of manganese by oxidation with bromine or persulfate in the regular course of analysis of rocks and soils has not been satisfactory because of incompleteness of precipitation of the manganese and, at times, contamination of the manganese precipitate with magnesium and the magnesium precipitate with manganese. To overcome these difficulties, it is suggested that the manganese be precipitated with the magnesium as the phosphate. The phosphates of manganese and magnesium are then weighed or titrated together, after which the manganese present is determined by means of the bismuthate method, and the amount of magnesium is determined by difference. In a number of tests this procedure has given satisfactory results. F.G.H.

Direct simultaneous microdetermination of carbon, hydrogen, and oxygen: II, Analysis of pure compounds

containing carbon, hydrogen, oxygen, and sulfur. W. R. KIRNER. *Ind. Eng. Chem., Anal. Ed.*, **7** [6] 363–65 (1935).—The direct, simultaneous microdetermination of carbon, hydrogen, and oxygen has been extended to include compounds also containing sulfur. Information was sought regarding the ultimate fate of the sulfur present in different types of linkage in organic compounds, after being subjected to combustion. It was found that regardless of whether the sulfur linkage is such that, on thermal decomposition, sulfur dioxide or trioxide is primarily formed, the sulfur appears in the final combustion gases as sulfur trioxide, although it is possible that exceedingly small amounts of sulfur dioxide may also be present. With regard to the mechanism of the reaction between oxides of sulfur and the absorbents present in the combustion-tube filling, it was observed that the sulfur trioxide is absorbed by the metallic silver present in the combustion-tube filling and is quantitatively retained as silver sulfate, an atom of oxygen being consumed in converting the sulfur trioxide to SO_4. Four analyses made on two different compounds indicate that the results are accurate to about 0.4 ± 0.1%. The errors in the method are primarily due to the rather large multiplication of errors made in the determination of carbon and hydrogen. The gasometric determination of the oxygen consumed is of satisfactory accuracy. Illustrated. For Part I see *Ceram. Abs.*, **14** [9] 228 (1935). F.G.H.

Flocculation in theory and practice. ANON. *Colliery Eng.*, **13** [2] 45 (1936).—A general review of the flocculation of colloidal dispersions with special reference to the clayey material in coal-washing effluents is given. Flocculation procedures as used at various mines with costs are presented. Influence of water properties on flocculation are particularly stressed. The study is concerned mainly with addition of lime, starch, or other colloids and various proprietary compounds to water to be clarified. G.T.

Glazes containing rare earths. D. TE HUI SHAW. *Jour. Chem. Eng.* [China], **1**, 7–19 (1934); abstracted in *Chem. Zentr.*, **i**, 610 (1936).—Lead metasilicate was chosen as ground glaze. It was mixed with the oxides of Ce, Pr, Nd, didymium, and Sm, and fired at 1000° for 4½ hr. in an oxidizing atmosphere. The measurements of the colors were made with an ordinary photoelectric apparatus. It was found that the color effects produced by rare earth in lead glazes are similar to the effects obtained by other pigments. The following relationships are of value: (1) color and saturation are linear functions of the log of concentration; (2) the log of reflection is a linear function of the root of concentration. The presence of rare earth in ceramic materials can easily be determined with reflection measurements according to S.'s method. It is interesting to note that the absorption characteristics of rare earths in silicate glasses do not differ considerably from those of watery solutions. M.V.C.

Identification of optically anisotropic crystals by their anisotropic effect between crossed nicols in reflected light. M. BEREK. *Zentr. Mineral. Geol. A*, No. 1, pp. 15–26 (1936).—The method described may be used for transparent as well as opaque anisotropic crystals. H.I.

Micro-electrolytic determination of bismuth and lead, and their separation by graded potential. A. J. LINDSEY. *Analyst*, **60**, 744–46 (Nov., 1935). H.H.S.

Minerals of the lead slags: Application of petrologic methods to slags. W. FABER. *Chem. Erde*, **10**, 67–115 (1935).—The crystalline compounds from lead slags, particularly the slags from the Unterharz region, were studied by petrographic, metallographic, and chemical methods and the optical and physical properties determined. The system CaO–FeO–SiO_2 can be used to discover many of the relations in the lead slags. The minerals, fayalite, willemite, α-celsian, sphalerite, wurtzite, and magnetite were found in the slags studied. A diagram for the optical and density relations in the system γ $2CaO \cdot SiO_2$–$2MgO \cdot SiO_2$–$2FeO \cdot SiO_2$ is given. An incomplete solid-solution series between willemite and fayalite is suggested. A member of the melilite series occurring in lead slags is identified as justite. Pyroxenes in lead slags are generally Al_2O_3-poor and are closely related to hedenbergite. Spinels, particularly magnetite and frequently zinc spinel, are abundant in lead slags. Sphalerite, wurtzite, and pyrite crystallize from the slag. H.I.

Notes on the J. Lawrence Smith fusion. M. O. LAMAR, W. M. HAZEL, AND W. J. O'LEARY. *Ind. Eng. Chem., Anal. Ed.*, **7** [6] 429–31 (1935).—There have been pointed out several sources of possible disagreement between different analysts over the alkali content of the same material when using the standard J. Lawrence Smith fusion. Since different substances are not thereby decomposable to the same extent, it has been suggested that the samples first be ground to some standard size, that the fusions be made at a higher temperature than is now customary, that the calcium carbonate and ammonium chloride flux be mixed together by ball-milling, and that correction of the mixed chlorides for accompanying magnesium be appropriately emphasized. The suggested improvements have been applied in the analysis of so-called β-alumina. F.G.H.

Optical and spectrographic investigations of beryl, especially at high temperatures. ROBERT BÖSE. *Neues Jahrb. Mineral. Geol.*, **70A**, 467–570 (1936).—The spectral analysis as well as the indices of refraction (between 4047 and 7699Å for eleven lines of the Mg spectrum, the red K and the yellow Na lines), double refraction, dispersion, and dispersion of the double refraction were determined on a number of beryl specimens at ordinary as well as elevated temperatures. The index of refraction, double refraction, dispersion, and dispersion of the double refraction show a close relation to the density. Changes of refractivity with temperature were measured on 3 beryls up to 800°C and on one up to 1150°C. Up to 800° the index of refraction, double refraction, and dispersion *increased* with the temperature. The temperature of disintegration of beryls due to sudden expansion in the direction of the *c* axis was determined. Crystals free of inclusions disintegrated at higher temperatures than inclusion-rich crystals. Alkali-bearing crystals disintegrated at lower temperatures than alkali-free crystals. H.I.

Oxide reactions and their importance in the silicate industries and slag chemistry. J. ARVID HEDVALL. Read before the Spring Meeting, Swedish Soc. Chem. and Mining, May, 1935; *Tek. Tid.*, **65** [21] 41–46 (1935).—A theoretical discussion of sintering and smelting phenomena and the effect of various components, such as the oxides of Fe, Cu, Zn, Al, and Co, is given. The ability of

SiO_2 to react in the solid state, a reaction between CaO and silicates or spinels and between SiO_2 and FeS_2, and the conditions for thermal decomposition of dolomite are also discussed. B.H.S.

Preparation and properties of mono-, di-, and tri-calcium phosphates. H. W. E. LARSON. *Ind. Eng. Chem., Anal. Ed.*, **7** [6] 401–406 (1935).—Methods of preparation and physical and chemical properties of the three phosphates are presented in great detail. F.G.H.

Reactions between solids in the system CaO–MgO–SiO_2 in the temperature range 600° to 1200°C. N. W. TAYLOR AND F. J. WILLIAMS. *Bull. Geol. Soc. Amer.*, **45** [7] 1121–36 (1935).—Intimate mixtures of dry solids in the system CaO–MgO–SiO_2 have been subjected to heat treatment at 600°, 800°, and 1200°C for 20 hours and at 1100°C for 104 days. The products were examined by X-ray for identification. All the anhydrous compounds of the system, except merwinite, were made in this way. The nature of the reaction products is largely determined by the diffusion mechanism, although eventually equilibrium factors predominate. Thus, lime-silica mixes reach equilibrium more easily than magnesia-silica mixes, and magnesia has a tendency to displace lime from silicate combinations. The order of the ease of formation of the various solids agrees with that derived from field observations of thermal metamorphism. A.C.B.

Ternary system FeO–MnO–SiO_2. W. R. MADDOCKS. *Iron & Steel Inst., Carnegie Schol. Mem.*, **24**, 51–68 (1935); abstracted in *Jour. Iron Steel Inst.*, **132** [2] 388 (1935).—The ternary diagram FeO–MnO–SiO_2 has been studied by methods of thermal analysis. The melting surface of a wide range of compositions has been determined. A ternary eutectic appears at a composition of 50% FeO, 20% MnO, and 30% SiO_2, which melts at 1170°C. A phase diagram of the system has also been constructed from the approximate measurement of the various constituents present in the solid melts. A brief résumé of the usefulness of the diagram in understanding acid open-hearth slags and the deoxidation of steel is given.

Thermodynamic functions of aluminum, α-aluminum oxide, β-graphite, oxygen, and carbon monoxide. L. TEREBESI. *Helv. Chim. Acta*, **17** [4] 804–19 (1934); abstracted in *Referat. Silikatliteratur*, No. 2108 (1935). M.V.C.

Three kaolins. D. BELYANKIN AND W. IVANOVA. *Zentr. Mineral. Geol. A*, pp. 298–308 (1935).—The chemical composition, heating curves, and temperature-weight loss (dehydration) curves are given for (1) a compact kaolin from Saglik, (2) an asbestos-like kaolin from Saglik, and (3) a compact halloysite from Aidyrly. In the dehydration curves of these clays, four different temperature ranges were distinguished, each corresponding to the removal of a different kind of water, (*a*) halloysite water (room temp. to 110°C), (*b*) zeolitic water (110° to 300°C), (*c*) zeolitic-constitutional water (300° to 400° C), and (*d*) water absorbed by the products of the dehydration (400° to 850°C). In the temperature-index of refraction curve of sample (3), four analogous regions were discovered and a further subdivision of the fourth region into regions corresponding to changes in dehydration products such as (d_1) the gradually increasing crystallization of γ-Al_2O_3, (d_2) the reaction of γ-Al_2O_3 with SiO_2 to form mullite (or sillimanite), and (d_3) the gradually increasing crystallization of mullite with temperature. H.I.

BOOK

Organic Solvents. ARNOLD WEISSBERGER AND ERICH PROSKAUER. 212 pp. Oxford, 1935. Price $5.00. Reviewed in *Sci. News Letter*, **28** [760] 288 (1935).—This is an English translation of an original German manuscript. Tables showing the physical constants of 157 important organic solvents are given. The literature of nonaqueous solutions is brought up to date. A bibliography of 1406 references is included. H.S.

PATENTS

Manufacture of an improved vitreous material. A. W. H. WEDLOCK. U. S. 2,032,239, Feb. 25, 1936 (June 10, 1935). In the method of manufacturing a vitreous material, the steps of reducing predetermined quantities of boric acid and alkali carbonates to comparatively fine powders, mixing the substances and heating the mixture to a temperature sufficiently high to drive off the water of crystallization and produce a frit, but not high enough to produce fusion or vitrification of the frit, reducing the frit to a comparatively fine powder, admixing the frit with powdered mica of substantially the same fineness as the frit in the presence of a small quantity of water, and heating the product to a temperature sufficiently high to initiate plasticity therein.

Method of recovering potassium sulfate from syngenite. H. H. STORCH AND NATHAN FRAGEN (United States of America). U. S. 2,033,159, March 10, 1936 (Aug. 30, 1933).

Process for making glass, enamels, glazes, etc., containing lead. PAUL BEYERSDORFER. U. S. 2,033,103, March 3, 1936 (March 16, 1932). In a process of manufacturing all kinds of lead-containing glass material, including glazes and enamels, adding substantially all of the lead ingredient in metallic form, together with an oxidizing agent which is sufficient to convert all of the lead into lead oxide by means of an oxidizing fusion, to a glass-forming mixture.

Process for the manufacture of alkali metal titanates. TITANGES. Brit. 443,155, March 4, 1936 (Aug. 22, 1933).

Process of producing calcined borax. W. H. ALLEN (American Potash & Chemical Corp.). U. S. 2,032,388, March 3, 1936 (March 11, 1929; Sept. 24, 1934). A process of producing a calcined borax of relatively dense nature from relatively hydrated borax comprises subjecting the borax to the action of inert gas of progressively increasing temperature and decreasing absolute humidity while the calcination process proceeds, the increasing temperature being held throughout the calcining process below the temperature which will cause the borax to undergo melting and puffing, the humidity of the gas being at all times sufficiently low so that at the temperature of the gas, the gas is capable of absorbing water of crystallization from the borax undergoing calcination without incurring melting or puffing of the borax, the action of the heated gases on the borax being continued until a granular, dense, calcined product containing less than 21% water is produced.

Process for the recovery of potassium salts from minerals. E. P. PARTRIDGE AND NATHAN FRAGEN (United

States of America). U. S. 2,033,149, March 10, 1936 (July 18, 1934). A method for the treatment of polyhalite comprises extracting ground and calcined polyhalite at a temperature between 70°C and the atmospheric boiling point by means of liquors containing from 7 to 8 parts of potassium sulfate, 21 to 26 parts of magnesium sulfate, and 15 to 20 parts of sodium chloride per hundred parts of water, separating the hot extraction liquor by known means from the solid residue comprising essentially calcium sulfate, precipitating a solid-containing potassium sulfate and magnesium sulfate in approximately equimolecular ratio by cooling the extract liquor, separating the solid product from the mother liquor by known means, and using the mother liquor with additional water or dilute process liquors in the hot extraction of an additional quantity of ground and calcined polyhalite.

General

Conveyance of solid particles by fluid suspension. R. F. DAVIS. *Engineering*, **140** [3625] 1–2; [3629] 124 (1935).—The general principles embracing the conveyance of solid particles in both liquids and gases are given, and the theoretical results are compared with accepted practice. The mechanics of the process of horizontal flow are discussed and a mathematical theory is described. H.E.S.

Determination of foundation pressures on clay. M. A. RAVENOR. *Engineering*, **140** [3648] 642–43; [3649] 655–56 (1935).—The relation of pressure and settlement of structures are accurately represented by the equation $C = (P/m + I)^4$, where C = settlement (in.), I = elastic deformation (in.), P = intensity of load (lb. or tons per sq. ft.), and m = a coefficient (load-in. units). The application of the above formula to an important series of tests is presented. Its application in the design of foundations is also discussed. The formula has been applied successfully to the actual settlement of structures erected on soft clay. H.E.S.

Economic aspects of stoker applications. R. H. FORESMAN. *Paper Trade Jour.*, **98** [9] 33–36 (1934).—Analysis is made of the influence of stoker design on capital expenditures for the generation of power. Special emphasis is placed on the multiple retort stoker. C.B.J.

Fire-testing station of the Fire Offices' Committee. ANON. *Engineering*, **140** [3647] 618–19 (1935).—The most recent developments for testing the fire-resisting properties of the essential parts of buildings, such as walls, columns, and floors as well as doors and shutters, are described, and the new fire-testing station at Boreham Wood, Elstree, is illustrated. The building is adequate for heating test structures under load to a specific time-temperature curve with a maximum temperature between 1000 and 2300°F for a period of exposure varying from 30 min. to 6 hr. The three furnaces are heated with a mixture of coal-gas and air. The hydraulic press for load-testing has a capacity of 500 T. Another building houses the sprinkler-testing equipment which is also fully described. H.E.S.

Illumination in the glass industry and related industries. WALTER HAHN. *Glas & App.*, **16** [22] 209; [23] 219–21 (1935).—General factors to be considered when laying out the illumination of glass plants, distribution of light and lighting fixtures, and intensity of light are discussed; charts to assist in the calculation are given. M.H.

Industrial research. F. E. SMITH. *Engineering*, **139** [3616] 14 (1935).—Twenty-five years of progress in industrial research are reviewed. There is a change in the attitude of industry toward research, and the closer coöperation which is springing up between industries and between units of the same industry will continue to reduce the time lag between a scientific discovery and its industrial application. H.E.S.

Laws of a mass of clay under pressure. M. A. RAVENOR. Read before Inst. Civil Engrs., April, 1935; abstracted in *Engineering*, **139** [3619] 558 (1935). H.E.S.

National Physical Laboratory. J. E. PETAVEL. *Engineering*, **139** [3616] 15 (1935).—Twenty-five years of progress at the National Physical Laboratory are reviewed. H.E.S.

Program for Thirty-Eighth Annual Meeting, American Ceramic Society. *Bull. Amer. Ceram. Soc.*, **15** [3] 69–95 (1936).

Steam production. J. DEWRANCE. *Engineering*, **139** [3616] 51 (1935).—The past twenty-five years of steam production are reviewed. H.E.S.

Twenty-five years' progress. LORD WEIR. *Engineering*, **139** [3616] 9 (1935).—A survey of the progress of engineering during the last twenty-five years is presented. H.E.S.

BOOK

Transactions of the All-Union Scientific-Research Institute of Refractory and Acid-Resisting Materials (V.I. O.K.): Vol. 2. Moscow, 1934. 84 pp. Price 2R 75k. The research work, "Influence of Granulometric Composition of Grog on the Quality of Products," by D. N. Poluboyarinov and O. U. Gracheva discusses the authors' experiments in reference to the investigations by Fuller, Skola, Litzow, Rieke, Swain and Phelps, etc. The question of how to obtain a dense batch is considered and numerous tables and experimental data are of practical value. The authors' conclusions are worth attention although the scale of the experimentation is not large enough to make fundamental generalizations.

"Low-Grog and Grogless Refractory Materials," by D. N. Poluboyarinov and A. K. Karklit, discusses experiments carried out with "lean" clays containing fine-grained quartz, and products of self-combustion of gangues by winning coal near Moscow. The defect of the refractories thus obtained is their high firing shrinkage. The investigation will be of interest for those selecting the kind of fireclay refractories (grogless, low-grog, grog, and highly grogged) it is most desirable to produce from a given type of clay. S. I. PERKAL

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